THE EFFECTS OF DIFFERENTIATING INSTRUCTION

BY LEARNING STYLES

ON PROBLEM SOLVING IN COOPERATIVE GROUPS

A working thesis submitted

by

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to

LaGrange College

in partial fulfillment of

the requirement for the

degree of

MASTER OF EDUCATION

in

Curriculum and Instruction

LaGrange, Georgia

April 25, 2011

Abstract

It can be difficult to find adequate strategies when teaching problem solving in a standard based mathematics classroom. The purpose of this study was to improve students' problem solving skills and attitudes through differentiated instruction when working on lengthy performance tasks in cooperative groups. This action research studied for 15 days whether students in a treatment group (n = 28), who were grouped by learning styles (auditory, kinesthetic, and visual), would display greater ability learning the standards or display better attitudes towards problem solving when compared to a control group (n = 28) who were grouped in random cooperative groups. When the qualitative and quantitative data were analyzed, the results demonstrated that the treatment group did not show significant gains when compared to random cooperative groups.

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CHAPTER ONE: INTRODUCTION

Statement of the Problem

The Georgia Department of Education (2010a) has defined five process standards for Math I: "solve problems using appropriate technology" (para. 17), "reason and evaluate mathematical arguments" (para. 18), "communicate mathematically" (para. 19), "make connections among mathematical ideas and to other disciplines" (para. 20), and "represent mathematics in multiple ways" (para. 21). These process standards are to act as vehicles throughout the course to facilitate learning of performance standards. Performance standards are divided into three areas of study: algebra, probability and statistics, and geometry standards, which include: "radical, polynomial, and rational expressions, basic functions and their graphs, simple equations, fundamentals of proofs, properties of polygons, coordinate geometry, sample statistics, and curve fitting" (Georgia Department of Education [GaDOE], 2010a, para. 1).

In addition to the standards, the GaDOE provides performance tasks to ensure that teachers are facilitating student learning of the curriculum through problem solving paired with cooperative groups. Each performance task covers a multitude of Math I standards. For each given task, students are given a real-life scenario to read and then are guided through numbered problems designed to facilitate the discovery of Math I concepts through problem-solving. The National Council of Teachers of Mathematics [NCTM] stated that students are "expected to learn serious, substantive mathematics in classrooms in which the emphasis is on thoughtful engagement and meaningful learning" (as cited in Lowrie & Logan, 2007, p. 14).

In my personal efforts to implement performance tasks in the classroom, I have experienced resistance from the students. The range of ability levels is wide and the class as a whole struggles to varying degrees with the reading and writing required to respond to the questions in the task. Lawrence-Brown (2004) stated, “in a traditional class of 15-year-olds a teacher should expect a 10-year range of reading” (p. 36). Also, when working on the tasks, students do not communicate well when in groups nor when presenting their answers to the class. The challenge of having so many standards to teach in a single semester of Math I, coupled with the resistance from students to do the tasks, encourages teachers, not excluding myself, to revert to a more traditional style of teacher-directed instruction. Therefore, optimal learning of standards through problem solving does not occur.

This study examined the effects of grouping students by learning styles in order to determine if attitudes towards problem solving improved and if success in mastering standards increased.

Significance of the Problem

The problem of utilizing only traditional teacher-directed instruction is significant because students need to have opportunities to access and to learn standards through meaningful problems. Boaler (2008) stated “if students are not given opportunities to learn challenging and high-level work, then they do not achieve at high levels” (p.112). For students to achieve at high levels in a math class, they must not only know a list of formulas and algorithms, but also know how to apply these. As stated by Boaler (2008), “if young people are to become powerful citizens…they need to be able to reason

mathematically – to think logically, compare numbers, analyze evidence, and reason with numbers" (p. 7).

Levy (2008) stated that "students enter classrooms with different abilities, learning styles, and personalities….educators are mandated to see that all students meet the standards of our district and state" (p. 161). Teachers need to find adequate strategies that provide students with the support needed to achieve standards presented through problem solving. Differentiating instruction by a student's learning style is one such strategy. According to Lawrence-Brown (2004), "with suitable supports, including differentiated instruction, students ranging from gifted to those with significant disabilities can receive an appropriate education in general education classrooms" (p.34).

Theoretical and Conceptual Frameworks

This research study is aligned with the fundamental ideas of constructivism. Benjamin (2002) believed that "the pedagogical theory that guides differentiation is constructivism: the belief that learning happens when the learner makes meaning out of information" (p. 1). Because this research study tested the effectiveness of differentiated instruction through problem solving exclusively, the alignment with constructivism is further strengthened. Chapman (2006) explained the importance of problem solving when he stated, "the goal should be to help students construct for themselves a deep understanding of when, what, how, and why context could aid or hinder mathematical thinking in arriving at mathematical solutions to word problems" (p. 228).

Because the students worked through the problems in groups for this study, this style of instruction more closely modeled social constructivism, rather than Piaget's

cognitive constructivist model. As cited by Powell and Kalina (2010), "Lev Vygotsky, the founding father of social constructivism, believed in social interaction and that it was an integral part of learning" (p. 243) and "according to Vygotsky… cooperative learning is a part of creating a social constructivist classroom" (p. 244).

The performance tasks used in this research "allow students to learn by investigating situations with a real-world context" (GaDOE, 2010b, p. 5). Therefore, this study is concurrent with the LaGrange College Education Department's (2008) Tenet 2, Exemplary Professional Teaching Practices, which states that "learning is mostly an affective, dramatic, and emotional event and that it requires learners to construct new connections" (p. 5). Tenet 2 explicitly states that differentiated instruction is a method that offers approaches such as cooperative learning.

By researching ways to improve students' problem solving skills and attitudes towards solving problems in which students are grouped by learning style, the research best supported the LaGrange College Education Department's (2010) Competency Cluster 2.2, Instructional Skills which states, "learners become more receptive to new information that is scaffolded upon prior knowledge…and must be applied in meaningful ways to ensure transference to other situations…" (p. 7). Furthermore, differentiated instruction was used in the study to see how it affected students' knowledge and attitudes. As implicated in Cluster 2.2, by the LaGrange College Education faculty when they wrote, "we advocate differentiated instructional processes that begin with teaching for conceptual understanding, move to presentation of knowledge…which they can apply this new information in active, meaningful;, and cooperative ways" (p. 7), it is evident that the research is clearly in line with the ideals of the Conceptual Framework.

A reflective journal was used to collect qualitative data to help discern how the attitudes of the students towards problem solving were affected by this study. This process is aligned with “Tenet 3: Caring and Supportive Classrooms and Learning Communities, Competency Cluster 3.1 Reflection” which states, “reflection involves writing and discussing feelings about classroom, school, and community experiences” (LaGrange College Education Department, 2010, pp. 8-9). This reflective process is also aligned with the state standard for teaching, “6.4 systematically reflect on teaching and learning to improve their own practice” (Georgia Systemic Teacher Education Program [GSTEP] & The University of Georgia [UGA], 2005, para. 7).

“Domain 5.2: plan and carry out instruction based upon knowledge of content standards, curriculum, students, learning environments, and assessment” (GSTEP & UGA, 2005, para. 6) of the Georgia Framework for Teaching was also implemented when artifacts, such as teacher lessons plans, were written and revised. Tomlinson stated that differentiated instruction was “an organized yet flexible way of proactively adjusting teaching and learning to meet students where they are and to help all students meet maximum growth as learners” (as cited by Rose, 2009, p. 23).

Proposition 4 of The National Board of Teaching Standards, states that teachers must think “systematically about their practice and learn from experience” (National Board of Teaching Standards, 2010, para. 5). This research accomplished this goal, by providing measurable data that can influence teaching strategies to better serve students.

Focus Questions

Through action research, the purpose of this study was to improve students' problem solving skills and attitudes when working on lengthy performance tasks in groups. Three focus questions were formulated to determine whether or not differentiated instruction methods facilitate learning when applied to performance tasks in a group setting. The following focus questions guided the research and targeted three specific areas:

Focus Question 1 (pedagogical content approach): How can differentiating instruction by student learning styles be implemented in the classroom while students are learning state mandated problem solving standards?

Focus Question 2 (student learning outcomes): On unit tests, how do the students who were grouped by learning style differ from the students who were not?

Focus Question 3 (reflective practices): How do attitudes towards learning standards through problem solving in groups change when differentiated instruction by learning styles is utilized?

Overview of Methodology

This study was conducted as participatory action research with two ninth grade classes of twenty-eight students in each. One class worked on a performance task in randomly assigned cooperative sub-groups and one class had sub-groups that were differentiated by learning style. The study took place over a four-week period. To

determine the effect of differentiating instruction by learning styles on students' learning or attitudes, both qualitative and quantitative data were collected and analyzed.

A pre-and post-survey was given to all of the students to detect change in attitudes towards working on the performance tasks in groups. Furthermore, a learning style survey was given to every student in the treatment group to determine attitudes toward working in groups that were differentiated by learning style. Qualitative data were obtained through a reflective journal noting behaviors related to the focus questions.

Also, a pre-and post-summative assessment was used to ensure that there was no significant difference between the two classes prior to the study. This summative assessment also provided quantitative evidence by setting a baseline to facilitate the determination of significant changes in learning of the standards when the tasks were presented using differentiated instruction. The scores were analyzed using independent and dependent t-tests to determine if there was a significant difference between pre-and post-test for each class and if there were significant differences between the post-tests for both classes.

Human as Researcher

I am a highly qualified secondary mathematics teacher with thirteen years of experience. Even with this experience, I strive to learn new methods to help students achieve. Calhoun stated that "educators who engage in action research are able to create instructional opportunities that are more effective and more intentional for student learning" (as cited by Hendricks, 2009, p. 23). In order for catalytic validity to be obtained, this entire research process was conducted both ethically and accurately.

Chapman (2006) studied how teachers approached teaching word problems by favoring one of two types of knowing, either paradigmatic knowing or narrative knowing. He explained "paradigmatic knowing in relation to word problems would require …mathematical models…that are universal and context-free" (p. 216). Narrative knowing teachers focus mainly on the contextual features of the word problems. When solving word problems, I am prone to strip away the context and look only to the math. Chapman suggested teachers should strive to achieve a balance of paradigmatic and narrative knowing to better reach students on both ends of the spectrum. Understanding that I am the type of learner who approaches a word problem as a paradigmatic 'knower' empowers me to make a choice *not* to diminish the intent of students learning the standards through a word problem. My awareness helps me remember "in general, then, students' knowledge of context should not be suppressed but treated as valuable to enter and exit the solution process" (Chapman, 2006, p. 228).

CHAPTER TWO: REVIEW OF THE LITERATURE

Benefits of Differentiated Instruction

Differentiated instruction is a philosophy that provides a variety of options in order to reach targeted standards (Gregory & Chapman, 2002). Heacox (2002) defined the beneficial aspects of differentiated instruction as “a way of thinking about teaching and learning and also a collection of strategies that help you better address and manage a variety of learning needs in your classroom” (p.1). Gregory & Chapman (2002) also addressed the varying levels of ability by further defining differentiated instruction as a “philosophy that enables teachers to plan strategically in order to reach the needs of diverse learners in classrooms today” (p. x). Lawrence-Brown (2004) advocated for differentiated instruction in order to “maximize achievement of general curriculum standards” (p. 36).

Differentiated instruction is student focused rather than teacher focused (Aaronsohn, 2003; Benjamin 2006; Lawrence-Brown, 2004; Tomlinson, 2001). The readiness of the learner is important to consider when implementing this philosophy. Benjamin (2002) stated that differentiated instruction benefits students because it is a “constructivist practice” (p. 31). Heacox (2002) explained that the goal of differentiated instruction is to “enhance learning for all students by engaging them in activities that better respond to their particular needs, strengths, and preferences"(p. 1). Students benefit from differentiated instruction because they are given choices and take ownership in their learning (Benjamin, 2002; Boaler, 2008).

Implementation of Differentiated Instruction

There are many ways to differentiate instruction, but certain ideals should be evident when implementing this philosophy. Lawrence-Brown (2004) proposed three implementation guidelines: begin with a high-quality lesson, promote active learning through multiple presentations, and connect with student interests. Northey (2005) promoted similar criteria for teachers when differentiating instruction: "get to know your students, gather resources, determine the best process, plan strategies for evidence of learning, and put all work into unit and daily plans" (p. xi).

Teachers can choose to differentiate instruction by content, process, or product (Gregory and Chapman, 2002; Levy, 2008). When teachers allow for variation of content, the standards should not be compromised, but instead tiered. Benjamin (2002) explained that, "tiered assignments, usually presented in three levels, are tasks that are constructed with different levels of depth and complexity in mind" (p. 35). Differentiated instruction by process addresses the vehicle by which the standards are taught to accommodate for different abilities or learning styles. Students who receive differentiated instruction by product are given choices as to how they are able to present what they know. In order for teachers to adjust the lessons for the learner, appropriately assessing prior knowledge and analyzing trends in learning is key (Gregory & Chapman, 2002; Rose & Arline, 2009). Student preference should also be considered when planning to differentiate instruction (Benjamin, 2006; Solomon, 1998; Tomlinson, 2001).

Resistance to Differentiated Instruction

Although there is clear evidence to support differentiated instruction as a better pedagogy to maximize student mastery of the standards, there are many classrooms in which no differentiation is taking place. The literature reveals that teachers may resist using differentiated instructional methods because, as Aaronsohn (2003) stated, “the traditional classroom feels right because that has been a familiar one for us teachers as students” (p. 145). Solomon also noted that “unfortunately, choices are sometimes based on factors such as habits and comforts of practice…instead of what will accomplish a particular desired outcome” (p. 80).

Burz and Marshall (1996) attributed pressures that teachers face when they stated, “because of the focus on content related to a particular content discipline, textbooks, and curriculum frameworks influence what is taught, the result has been to teach the facts without using a meaningful learner-centered approach” (p. vii). Teachers also succumb to pressures and avoid a differentiated class and choose a traditional classroom because the teacher believes that it is faster and easier for students to learn in this manner. Aaronsohn (2003) rationalized that “it is often much easier for a teacher to make meaning for the students, because it usually saves time and prevents a situation wherein the teacher may lose control of the class discussion” (p. 163).

Some teachers struggle with allowing the students to be the center of attention in the classroom. Aaronsohn (2003) explained that “the stage-and-audience arrangement that traditional classroom arrangements set up can be seductive to any teacher…it is easy to enjoy the performance high” (p. 145). Solomon (1998) echoed what Aaronsohn

explained and stated, “teaching has frequently been described as a performance…. perhaps it may be useful to take the students out of the audience, place them into the action as performers” (p. 80).

Students may also resist new instructional methods and prefer a traditional classroom setting. Aaronsohn (2003) stated, “it is not surprising that students act the way we have trained them to act…dependent on us, docile, and unwilling to listen to peers, and fearful of sharing half-formed ideas..”(p. 163). Students have grown accustomed to being able to find the answer so quickly, that they do not like to struggle with a problem. As Cotic and Zuljan (2009) stated, a good problem should create a good frustration level and should feel like a problem situation and not as an exercise or routine.

Benefits of Cooperative Groups in a Differentiated Classroom

Differentiating instruction works best when students can collaborate (Tomlinson, 2001). When students are afforded instruction that requires them to make choices, be active in their learning, and produce high quality work, they need to be given the opportunity to converse with one another and work cooperatively. Tomlinson (2001) explained how cooperative groups play an integral part in a differentiated classroom as, “students collaborate ….and can make major contributions toward solving problems” (p. 23). Although White and Dinos (2010) do not advocate for cooperative groups when the collaborators differ in background knowledge, they do give four guidelines to determine when cooperative groups could be beneficial: cooperation is imperative for the task that could not be completed alone, all collaborators are novices at the task, the group

constructs a shared representation of the task, and they are to coordinate their background knowledge.

Implementation of Cooperative Groups

Solomon (1998) suggested teaching standards and enabling activities “that include a heterogeneous classroom organized into within-class groups that have both individual accountability and interdependence are desired because they increase the potential to accomplish content and performance standards…which should include skills necessary for collaborative effort” (p. 83). Adequate teacher preparation and small group sizes of three to four students increase the positive effects of organizing students into small groups (Solomon, 1998). When students are working cooperatively, they must first spend time defining the problem and then discuss how the problem should be solved (Benjamin, 2006; Cotic & Zuljan, 2009). Cooperative groups can be chosen by the teacher or by the students, can be chosen randomly or by student ability or preference, should all work on the same task or on one facet of the same task, and may be purposefully mixed as to learning needs and academic strengths to provide peer instruction or leadership with groups (Heacox, 2002).

Attitudes Towards Cooperative Groups

When working on authentic problem solving, students should have each other as a resource and have the ability to help each other and talk through the math (Boaler, 2008). Cotic and Zuljan (2009), Lowrie and Logan (2007), and Benjamin (2006) also stressed the need to provide students the ability to cooperatively work with their peers. Ediger (2009) stated that cooperative learning gives students a feeling of worth in the classroom

and help them develop well emotionally. Another benefit to cooperative learning is that students gain respect from their peers by sharing ideas and conveying the math concepts through their work in groups (Ediger, 2009).

Although most of the literature conveys how cooperative groups in the classroom resulted in positive attitudes towards problem solving, opposing literature should also be noted. White and Dinos (2010) studied the benefits of prior training on cooperative groups. White and Dinos (2010) described the training that thirteen year old students in the treatment group received, which taught them "to develop trust, effective communication, and group cohesion to increase on-task communication during peer-cooperative problem-solving exercises" (p.230). The study resulted in no significant difference in pre-post tests, but did show more on task behaviors within the group who received the prior training (White & Dinos, 2010). Kneser and Ploetzner further developed the belief that cooperative learning is not always the best option when they stated the benefits of cooperative learning, "depend[s] on the background knowledge of the collaborators…as demonstrated by their post-test, the qualitative students learned more from their quantitative partners, suggesting that the benefits of cooperation are not always equal for all partners" (as cited in White & Dinos, 2010, p. 227). Lastly, White and Dinos (2010) expressed more concerns in regards to the benefits of cooperative groups when they stated, "a closer analysis of the children who regressed revealed that they lack confidence in their answers during cooperative problem solving….especially prone to regression when paired with individuals who were confident in the inaccurate answers" (p. 227).

Benefits of Problem Solving in a Differentiated Classroom

The differentiated classroom works well in cooperative groups that require meaningful problem-based work (Cotic & Zuljan, 2009; Lowrie & Logan 2007). Jausovec (1993) defined a high quality problem to have three main components: “undesired initial situation, a desired end situation, and an obstacle preventing the passage from the initial to the desired end situation” (as cited by Cotic & Zuljan 2009, p. 298). In order to benefit student learning, Boaler (2008) instructed teachers to incorporate four key strategies when teaching mathematics: questioning, reasoning, allowing for multiple mathematical representations, and using flexibility of numbers. These strategies are best implemented through problem solving.

Implementing Problem Solving

There are five criteria for essential problem solving: some problems should contain insufficient amount of data, others should contain more data than needed, some should contain multiple-solutions, some should have various ways to solve the problem, and some solutions should have contradictory data or no solution at all (Cotic & Zuljan, 2009). Problems should rely on the students own past experiences and knowledge (Cotic & Zuljan, 2009; Lawrence-Brown, 2004; Lowrie & Logan, 2007; Rose & Arline, 2009; Solomon, 1998). Problems should also engage students by providing them situations that are personal and meaningful (Cotic & Zuljan, 2009; Lowrie & Logan, 2007; Rose & Arline, 2009).

Attitudes Towards Problem Solving

Cotic and Zuljan (2009) clearly define needed problem-based instruction for a performance task by describing distinctions between a problem and an exercise. An exercise is a traditional teaching process where a procedure is demonstrated by the teacher and a strategy is given for solving. The students then practice this exercise on similar examples using the same procedures. Coctic and Hodnik (2002) stated that as a consequence, "the students come to believe that any problem can be solved without particular mental effort, and when the way to the solution is not immediately obvious, the students are easily persuaded that the problem cannot be solved" (as cited by Cotic & Zuljan, 2009, p. 298). Boaler (2008) also rebuked passive approaches to problem solving stating that, "they do not view themselves as active problem solvers" (p. 41).

According to Benjamin (2006), Coctic and Zuljan (2009), and Boaler (2008), problems should be "open" work that can be accessed and taken to different levels with various ways to solve the problem. Coctic and Zuljan (2009) provided reasons, including giving students a feeling of success and independence when working on authentic problems rather than "traditional math instruction that involves mainly single-solution problems" (p. 300). Burz and Marshall (1996) conveyed how students respond positively to problem-based curriculum "… when students begin to recognize and improve their competence with each new learning performance" (p. 4). Boaler (2008) also made a distinction between student attitudes towards problem-based learning found on a performance task instead of "small problem" exercises when she stated, "when a teacher…finds challenging problems…these are also the most interesting problems in mathematics so they carry additional advantage of being more engaging" (p. 118).

Benefits of Differentiating Instruction by Learning Style

Classrooms that are organized according to learning style naturally promote learning. Learning style, as Dunn, Beaudry, and Klavas (2002) stated, “is a biologically and developmentally imposed set of personal characteristics…as individual as a signature..”(p. 75). As Montgomery (2000) explained, “I can only learn well and easily in the way that is natural for me….almost four-fifths of learning style is biologically imposed” (p. 43). Dunn, Beaudry, and Klavas suggested that “individual responses to sound, light, temperature, design, perception, intake, and mobility needs are biological” (p. 87).

Grouping students by learning style rather than homogeneously is beneficial to students. Students learn best when they can make meaning of the standards for themselves as opposed to a traditional classroom in which the teacher makes the meaning for them (Aaronsohn, 2003; Read, 2000). Lawrence-Brown (2004) stressed the importance of using differentiated instructional methods when he stated, “given the availability of strategies such as differentiated instruction, responsible pedagogy no longer allows us to teach as if students all learned in one way, and at the same pace”(p. 36).

Working in groups according to learning style is helpful to students as they can obtain information from other students when their teacher may not be presenting material in their learning style (Dunn, Beaudry, & Klavis, 2002). Instructors who teach traditionally are participating in what Montgomery (2000) stated as “naturalizing” (p. 43) his/her own teaching style. The styles that work for the teacher are usually

analytic/auditory and visual styles because that it is what he/she knows from being taught in traditional classrooms. Montgomery (2000) also explained the disparity between a teacher's style and the students learning style when he stated, "65 percent of teachers are strongly analytic and 50-60 percent of secondary students are strongly global…therefore prospective teachers need to see manipulatives and whole-body activities for teaching global students…to reach these too often ignored students"(p. 46). Global learners who require more mobility in the classroom can be negatively viewed as distracters in a traditional classroom setting, where physical activity is prohibited (Dunn, Beaudry, & Klavis, 2002; Montgomery, 2000). Dunn, Beaudry, & Klavis (2002) stressed the need to meet the needs of all learners by stating, "identifying learning styles as a basis for providing responsive instruction has never been more important than now, as educators meet the needs of a diverse student population"(p.88).

Differentiating instruction by learning style is a solution to meeting the needs of a broad spectrum of students and to ensuring that all students achieve the standards of district and state, which is one of the biggest challenges for teachers (Heacox, 2002; Levy, 2008). Dunn, Beaudry, and Klavis (2002) promoted differentiating by learning styles when they stated, "when permitted to learn difficult academic information or skills through their identified preferences, children tend to achieve statistically higher on test and attitude scores than when instruction is dissonant with their preferences"(p.88). As Read (2000) stated, differentiating by learning style will allow students to "interact with course content to facilitate memory retention and to use higher order thinking skills" (p.40). Dunn, Beaudry, and Klavas (2002) also discussed the correlation between student

mastery of concepts and learning style when they stated, "most children can master the same content; how they master it is determined by their individual needs" (p. 88).

Grouping students by learning style is a better choice for teachers than grouping by ability because it is more beneficial for student learning. Dunn, Beaudry, and Klavas (2002) explained this gained benefit when they stated, "no learning styles is either better or worse than another…since each style has similar intelligence ranges, a student cannot be labeled or stigmatized by having any type of style" (p. 88). Boaler (2008) noted two studies, 1999 Third International Mathematics and Science Study (TIMSS) (studied eighth grade students in 38 counties) and the Second International Mathematics and Science Study (SIMSS) (conducted from 1982 to 1984), both of which had findings that nations who did not use ability grouping had the highest levels of achievement. Ability grouping focuses on comparing what the student knows about the content to others in the class which can be detrimental to student achievement whereas grouping by learning style focuses on what students can do with what they know (Burz & Marshall, 1996; Read 2000). Montgomery (2000) stated, "I have understood that learners have their own individual strengths and that teachers need to help them identify and use them independently" (p. 44)

Grouping students by learning style promotes a community of learning in which each learner takes responsibility for his/her learning. Gregory and Chapman (2002) asked teachers to consider, "that community is the entity which individuals derive meaning" (p. 4). Read (2000) also noted that because the students work with the focus on their own learning style, students take ownership of their learning. Read (2000) who utilizes student learning styles in her classroom, shared that the outcome when she wrote,

"invariably a learning community emerges that always surprises the students and never fails to please me.."(p. 40).

Implementing Differentiating Instruction by Student Learning Style

Northey (2005) defined "a learning style is a preference for the method by which an individual learns something and how that individual remembers what has been learned" (p. 10). In order to determine student learning styles, teachers must first assess the students using a learning styles survey (Gregory & Chapman, 2002). Northey (2005) and Heacox (2002) categorized three learning styles: visual, auditory, and kinesthetic/haptic learners, while Gregory and Chapman (2002) listed five categories: auditory, visual, tactile, kinesthetic, and tactile/kinesthetic learners. Levy (2008) provided four types that align with the three categories that Northey and Heacox listed but added a verbal learning style.

Visual learners learn best through their sense of sight (Northey, 2005; Gregory & Chapman, 2002). Students who are visual learners process information most effectively when they can see what they are learning (Heacox, 2002). Also, learning takes place best for visual learners when they can read the information presented (Gregory & Chapman, 2002).

To differentiate for visual learners, student should be provided with materials that they can process through reading, writing, and observing (Heacox, 2002). Gregory and Chapman (2002) gave examples of written materials that are useful to visual learners, including illustrations, pictures, graphic organizers, and diagrams that are preferably in color rather than black and white. Northey (2005) listed various methods to differentiate

for visual learners, such as allowing them to see a film that explains the information, to memorize by using flashcards, to find a quiet place to study, to doodle while learning, and to see pictures when reading and writing.

Auditory learners learn best by processing information through what they hear (Northey, 20005; Heacox, 2002). They absorb spoken and heard material easily (Gregory & Chapman, 2002). Rather than reading materials, aural questioning is preferred with auditory learners (Gregory & Chapman, 2002).

Auditory learners prefer listening to lectures, stories, and songs; they enjoy variation such as voice inflection and intonational pitch; they like to discuss and use opportunities to talk about their learning with other students (Gregory & Chapman, 2002). Northey (2005) also gave ways to differentiate instruction for auditory learners: listen to someone speak the information, memorize by repeating information to a partner or self, find a place to study out loud, have music playing while learning, hear the writer's words when reading, and discuss information to help make it memorable. Heacox (2002) stated the best way to meet the needs of auditory learners is through oral presentations and explanations.

Kinesthetic / tactile / haptic learners work best when they can manipulate objects or materials by doing, touching, or moving (Heacox, 2002). Northey (2005) defined their learning "by doing or experiencing, which includes kinesthetic, olfactory, and tactile learning" (p. 10). Gregory and Chapman (2002) explained that kinesthetic learners learn best by, "becoming physically involved in learning activities that are meaningful and relevant in their lives" (p. 20).

Gregory and Chapman (2002) gave ways to differentiate for kinesthetic/haptic learners by allowing them to role-play and act out simulations in order to give freedom to move about the classroom. Northey (2005) defined instructional support for kinesthetic/haptic learners as doing activities or labs to experience the information, memorizing by remembering and experiencing information, finding a place to move around while studying, getting a chance to try different ideas while learning, and giving breaks when reading. Kinesthetic/haptic learners learn best whenever writing and drawing can be involved with concrete examples (Gregory & Chapman, 2002).

The implementation of task cards is an "effective resource for tactual learners at all levels" (Dunn & Dunn, 1993, p. 154). Dunn and Dunn (1993) explain that the focus of the cards to is help students learn standards about a "specific topic, concept, or skill" (p. 154). The cards are made initially from a large piece of poster paper that is cut into pieces like a puzzle. On one side of each puzzle piece is a question and on the opposite side of the puzzle piece is the answer.

Another method for categorizing learning styles groups students into two groups that may vary in names but can be used interchangeably: left / analytic / inductive and right /global /deductive (Dunn et al., 2002). Left / analytic / inductive students learn successfully in small steps leading to understanding and right / global/ deductive students learn by obtaining meaning from a broad concept and then focusing on details (Dunn, Beaudry, & Klavis, 2002). According to Dunn, Beaudry, & Klavis (2002), high school students who are global learners prefer music, low illumination, informal or casual seating, dislike structure, and are more peer motivated while analytic learners prefer a

conventional formal classroom seating design, more structure, less intake, and visual rather than tactile or whole-body activities or resources.

When differentiating by learning style, other factors that affect students are noise level, structure, individual versus peer work, temperature, time of day, and bright or soft illumination (Dunn, Beaudry, & Klavas 2002; Gregory & Chapman 2002). Some suggestions for accommodating these learning style preferences are: allowing students to either listen to music with headphones or to wear earplugs for quiet, adjusting student seating to light preferences either near or farther away from a window, giving students time to work in class or at home during their preferred work time, and suggesting the student wear layers to accommodate the preferred temperature (Northey, 2005). The best way to find out a student's preferences to these factors is to do a student survey (Northey, 2005).

Attitudes Towards Learning Styles

Read (2000) explained that students may be apprehensive initially to learning by their preferred learning style because they are used to learning in a traditional classroom setting, but after a few weeks, she stated that "the dislikes are few or non-existent"(p. 38). Lawrence-Brown (2004) stated that by allowing students to work in groups by their preferred learning style "recognizes and supports the classroom as a community to which age peers belong, where they can and should be nourished as individual learners"(p. 36). When students are able to use their learning style strengths, they are provided with more opportunities to learn and feel successful (Heacox, 2002). Differentiating instruction by learning style captures each learner's attention and capitalizes on the student's strengths,

resulting in increased achievement and interest (Gregory & Chapman, 2002; Dunn, Beaudry, & Klavas, 2002). Grouping students by learning style allows students to access, to process, and to express information in the most effective way for the student (Gregory & Chapman, 2002). Students who are involved in mathematics using their preferred learning style are more engaged learners (Dunn, Beaudry, & Klavis; Gregory & Chapman, 2002). Read (2000) noted that when she teaches by learning style, her classes report assignments given according to learning style, "peak learning experiences in this class"(p. 40).

CHAPTER THREE: METHODOLOGY

Research Design

An action research method was chosen for my study because I studied students that I teach. The purposes of this study was to improve my practice skills and to increase student learning by systematically defining a problem, developing three focus questions, gathering data, and then analyzing the data (Giles, Wilson, & Elia, 2010; Hendricks, 2009). A literature review was conducted to gain knowledge of best practices that could be incorporated into my instructional plan (Giles et al., 2010; Hendricks, 2009).

As suggested by Hendricks (2009), credibility was gained by collecting and analyzing multiple forms of data. Both qualitative data and quantitative data were gathered to compare the treatment group and the control group. For this action research study, triangulation was established by conducting student pre-post tests, performance task scoring rubrics, coded observations, student attitudes toward problem solving surveys, student attitudes toward grouping by learning style surveys, and a reflective journal.

Setting

The study site high school served a total of 1782 students: 529 ninth grade students, 463 tenth grade students, 427 eleventh grade students, and 363 twelfth grade students. Ninth grade students were taught in a separate Ninth Grade Academy building and have limited interaction with the upper grades. The student population was made up of the following student ethnicities: 0.1% American Indian or Alaskan Native, 1.7%

Asian or Pacific Islander, 4.9% Hispanic, 13.2% black, not Hispanic, 77.3% white, not Hispanic, and 2.4% Multi-racial. Special education students represented 10.8% of the student body.

For the past four years, this high school has scored above the state (Georgia) and national SAT total mean scores. Overall SAT totals (verbal, math, and writing) for 2006-2009 respectively for the high school: 1546, 1515, 1520, and 1542; overall totals for 2006-2009 respectively for the state/nation respectively: 1477/1518, 1472/1511, and 1466/1511. In 2009, the graduation rate for the high school was 89.3% which exceeds the bar by 9.3%. Ninety two percent of first time test takers in the eleventh grade passed the writing test. The Georgia High School Graduation Test (GHSGT) is another high stakes test. The high school's percentages who passed and the categories were: 96% English Language Arts, 97% Mathematics, 97% Science, and 92% Social Studies.

This research was conducted in a Math I classroom in the freshman building at a rural high school in Georgia. The setting was chosen because it is the classroom that I was currently employed to teach. Permission was granted by the county school system, the principal of the high school, and by the LaGrange College Institutional Review Board.

Subjects

The subjects for this action research were the students currently enrolled in my two Math I classes. These classes were selected because they share more similarities than any other two classes available for this classroom action research. The standards and sequence for both classes were identical. Both classes consisted of ninth grade

students who ranged from fourteen to sixteen years of age. Also, both classes were non-collaborative; therefore, I was the sole teacher for each class. One class served as my control group and the other as my treatment group. Each class met every school day for ninety minutes for one semester (January 5, 2010 through May 27, 2010).

In order to make comparisons between the two classes, data were collected by student and by class. The student data were collected by category: sex, ethnicity, truancy, grade history, Criterion-Referenced Competency Test (CRCT) scores from sixth through eighth grade, number of discipline referrals, gifted services, student support team (SST), and accommodations (such as behavior plan, 504, or IEP). Each category was then totaled and percentages were given by class. Although most of the data conveyed little difference between the two classes, the class that was more diverse by ethnicity and grade history was chosen as the treatment group.

The treatment group met daily from 10:10 a.m.-11:40 a.m. and was made up of twenty-eight students. There were sixteen females and twelve males. The ethnicity percentages were as follows: 62% white non-Hispanic, 21% black non-Hispanic, 10% Hispanic, and 7% Multi-racial. Two students out of twenty-eight had truancy issues. A student grade history was as follows: 45% made A’s/B’s, 31% had at least one C, 24% had at least one F. The CRCT scores for math were recorded for sixth, seventh, and eighth grade and are as follows: 38% all Meets, 28% Meets or Exceeds, 7% all Exceeds, 17% Meets or Does Not Meet, 3% all Does Not Meet, 7% no data available. 14% of the class had at least one discipline referral (excluding referrals regarding tardiness or cell phone confiscations). Out of the twenty-eight students, four were served by the gifted program and one student had a behavior plan.

The control group met daily from 2:00 p.m. – 3:30 p.m. and had an enrollment of twenty-eight students. There were fourteen females and fourteen males. The ethnicity percentages were as follows: 81% white non-Hispanic, 6% black non-Hispanic, 13% Hispanic, and no Multi-racial. Three students out of 28 had truancy issues. A student grade history was as follows: 61% made A's/B's, 29% had at least one C, 10% had at least one F. The CRCT scores for math were recorded for sixth, seventh, and eighth grade and were as follows: 23% all Meets, 39% Meets or Exceeds, 6% all exceeds, 29% Meets or Does Not Meet, 3% all Does Not Meet, 0% no data available. 13% of the class had at least one discipline referral (excluding referrals regarding tardiness or cell phone confiscations). Out of the twenty-eight students, three were served by the gifted program and one student was served under a 504 plan for a health issue.

Procedures and Data Collection Methods

The procedures and data collection methods were aligned with my focus questions and with research in order to improve pedagogy. The data shell below (see Table 3.1) shows how the focus questions, the literature, and the data collection are aligned and analyzed.

Table 3.1 Data Shell

Focus Question	**Literature Sources**	**Type: Method, Data, Validity**	**How are data analyzed**	**Rationale**
How can differentiating instruction by student learning styles be implemented in the classroom while students are learning state mandated problem solving standards?	Gregory, G. H., & Chapman, C. (2002) Heacox, D. (2002) Read, S. E. (2000)	Type of Method: Instructional Plan rubric and interviews Type of data: Qualitative Type of Validity: Content	Coded for themes: Recurring Dominant Emerging	Looking for categorical and repeating data that form patterns of behaviors
On unit tests, how do the students who were grouped by learning style differ from the students who were not?	Dunn, R., Beaudry, S., & Klavas, A. (2002) Montgomery, N. (2000) Read, S. E. (2000)	Type of Method: Teacher made Pre-post Test, Performance Task Grading Rubric Type of data: interval Type of Validity: Content	Independent T-test- compare pretests, post-tests for treatment group and control group Independent T-test - performance task scores of treatment vs. control group Dependent T-test- compare pre-post of treatment to control group and post-test of treatment group to control group	Independent T-test: To determine if there are significant differences between means from two independent groups Dependent T-test: to determine if there are significant differences between means from one group tested twice.
How do attitudes towards learning standards through problem solving in groups change when differentiated instruction by learning styles is utilized?	Aaronsohn, E. (2003) Boaler, J. (2008). Cotic, M.,& Zuljan, M. (2009)	Type of method: Pre-post Problem Solving Attitude Survey Learning Style Student Attitude Survey;Reflective Journal and Note-taking Rubric Type of Data: Ordinal Qualitative Type of Validity: Construct	Chi Square; Independent T-test Coded for themes: recurring, dominant, and emerging	Desire to find what questions are significant; To determine if there are significant differences between means from two independent groups Looking for categorical and repeating data that form patterns of behaviors

Classroom action research begins with a good instructional plan (Hendricks, 2009). To ensure that my instructional plan (see Appendix A) was acceptable, a panel of fellow employees assessed the instructional plan and all instruments used in implementing the plan using a rubric (see Appendix B). The instructional plan is based on the best practices that were reviewed in the literature.

The treatment group was divided into subgroups by learning style. Each student took a learning style survey to determine his/her learning style. Each sub-group consisted of four students. The control group was divided randomly into subgroups. The sub-groups also consisted of four students.

The control group and the treatment group were given a teacher written pretest (see Appendix C). The student names were coded C1-C28 for the control group and T1-T28 for the treatment group and the scores were recorded in excel to be used at a later date. The students in both groups also took a student problem solving attitude survey (see Appendix D). The students created a 4 digit code so they could be scored anonymously, while allowing me to pair each student's answers with the post survey. The Paula's Peaches performance task (on the GaDOE website), Paula's Peaches answer sheet (see Appendix E), and the grading rubric (see Appendix F) were be handed out to every student.

The students in the control were grouped randomly into sub-groups of four students in which they were to work cooperatively. Each sub-group was assigned two questions to present to the class and was given a piece of chart paper that was poster-board-size on which to write their answers. The students in the treatment group took a

Learning Channel Survey (see Appendix G). The students were grouped according to their learning style in groups of four students. The students were assigned two questions to present to the class and were given a Learning Style Menu (see Appendix H) to choose how they could present their answer.

Both the sub-groups in the control group and the treatment group received one yellow, one red, and one green cup. When the students felt comfortable working on the task, the students will display the green cup. When a group began to have trouble understanding a portion of the task, they displayed the yellow cup and would first discuss the issue with the other group members and define the problem. When the group agreed that teacher assistance was needed, the group would then display the red cup. At this time, I would assist the group with their problem with the task.

The treatment sub-groups who were grouped by learning style were categorized and referred in class as either a visual learner group, an auditory learner group, or a kinesthetic learner group. In addition to each learning style group being provided with a Learning Style Menu to differentiate the product that proved the understanding of the standards, each treatment sub-group was provided process differentiation through varied instructional techniques that was catered to their learning style.

As suggested in the literature, the visual learner groups began each day with five to ten minutes of silent reading (Dunn & Dunn, 1993). The visual students were provided with ear plugs to use during the silent reading in order to decrease auditory distractions (Northey, 2005). To provide more visual interaction with the visual learners, when they used their red cups to alert teacher assistance, the students were asked to

present the question in written form and the answer to the question was also given in written form. The students then chose one of three visual learner options from the Learning Style Menu to present their answers for two of the fifteen questions that were randomly assigned to their group.

The auditory learners began each day with five to ten minutes of listening to the task read aloud either by the teacher or from a member of the group (Dunn & Dunn, 1993). The auditory learners were encouraged to talk about the task at great length before answering the questions on the answer sheet. When the auditory learner sub-group displayed the red cup for assistance, they were asked to verbally ask the question and then assistance was provided through a discussion of the problem instead of written form (Dunn & Dunn, 1993).

Kinesthetic Learners began each day reading the new portion of the task that was cut into sections and pasted onto a task card. The material looked different, but was the exact same material, pasted onto task cards in order to provide more access for the kinesthetic learner (Dunn et al., 2002). When the kinesthetic learners used the red cup for assistance, they were shown the answer by making up some movement or visual. An example of movement was having the student show the shape of the quadratic with their arms.

To better align differentiation by learning style, each treatment sub-group will be given more flexibility on learning conditions such as noise level (Heacox, 2002). For example, when the kinesthetic group, had a question regarding writing an algebraic

expression for a particular question, they were given an area right outside the classroom to act it out.

When the sub-groups of the control group presented the red cup for assistance, I followed a traditional model. This model entailed listening to their questions, looking for the work they have on the Paula's Peaches Learning Task Answer Sheet, answering questions through verbal response and asking them to write those responses down (Aaronsohn, 2003).

During each class block for fifteen days, forty five minutes were spent on the task. At the end of the three weeks, students from the control group presented their posters to the class for each of the two questions over a two day period and submitted the Paula's Peaches answer sheet. As each group of four students presented their findings to the class, they were scored individually on a performance task rubric. After a percentage was calculated for each student, the answer sheet was taken into account as part of the score. For each question left incomplete, points were deducted from the percentage. The students in the treatment group were graded for problems they were assigned by the same rubric but on what they chose to present from the learning style menu.

Both treatment and control groups took a posttest identical to the pretest. They also took the problem solving attitude survey again and used the same four digit code that was provided on the initial survey.

As the data shell shows, a reflective journal was utilized to gather qualitative data to help determine if student attitudes towards problem solving improved when grouped by learning style. To facilitate my journal writing, a reflective note taking tool (see

Appendix I) and a list of reflective journal prompts (see Appendix J) was used. To further strengthen my qualitative findings, the treatment group also received a Learning Styles Attitudes Survey at the end of the study (see Appendix K).

Validity, Reliability, Dependability, and Bias

To strengthen the pedagogical approach of implementing differentiated instruction by student learning styles, an instructional plan was created and was reviewed along with the assessments and instruments by a panel of employees who closely represent all groups of students in this study according to race, gender, and ethnicity. The panel consisted of a Math I female Caucasian teacher who has taught the state curriculum since it was implemented in 2008, a female special education African-American teacher who has served students in a collaborative Math I classroom for the past three years, a female bilingual Hispanic custodian/school parent whose primary language is Spanish, and an African-American male principal. After each volunteer panelist reviewed the instructional plan, each member was given a Peer-review Instructional Plan Rubric to record pertinent feedback, which consisted of six open ended questions analyzing the effectiveness of the essential questions, appropriate materials and technology, special needs of learners, and alignment of assessments with standards. The panel was also interviewed and the feedback received provided additional raw data that was accurately recorded and utilized to improve the instructional plan, assessment, and other instruments. The instructional plan provided a framework to ensure the standards, performance task, essential questions, and time frame remained consistent for both the treatment group and the control group which further strengthened the dependability of this action research.

As Goldstein (1996) stated, “when constructing and examining assessments, it is very important to eliminate irrelevant features which may result in group differences” (p. 90). The panel provided item by item feedback as to whether any information should be changed or eliminated in the instructional plan or assessments as an effort to provide absence of bias to all instruments used in this study. Therefore no student was unfairly penalized because of sex, race, ethnicity, socioeconomic status, religion, or other such group-defining characteristics (Popham, 2008).

To better group the students in the treatment group by learning style, ordinal data was obtained. The students were given a Learning Channel Preference questionnaire. The students were given ten identifiable scenarios for each learning style to rate: 3-often applies, 2-sometimes applies, 1-almost never applies, or 0-never applies. The students then totaled the scores for each learning style. The learning style with the highest score was determined as the student’s learning style. Because the instrument was taken from another credible source (as cited in Appendix G), absence of bias, internal consistency, and construct validity evidence have already been established.

A pre-post test was given to provide interval data that determined if the students who were grouped by learning style differed in knowledge from the students who were not. To ensure the pre-post test adequately “taps the content of the curricular aim” (Popham, 2008, p. 56), content-related evidence of validity was gathered through developmental care. Because the differentiation of instruction through learning styles was implemented during problem solving in groups, the standards assessed in the problem solving task were determined and were then clearly defined in the instructional

plan. After the specific algebra standards were obtained and documented, the test was aligned with those specific standard elements.

Since the purpose of an assessment is to "assist in the learning process by providing an understanding of what someone has learnt so that remediation and further learning may take place" (Goldstein & Lewis, 1996, p. 2), careful consideration was made to the type and number of test items that were included on the pre-posttest. To ensure both of the standard elements were equally represented, eight of each element type was included. To further provide content validity, three colleagues and a parent who work at the school were asked to read the test and to provide qualitative feedback (Salkind, 2010). The pre-post test was included with the instructional plan and the panel provided feedback to ascertain that the test items were a good representation of the standard elements.

To ensure test reliability over time, test-retest reliability was obtained by giving the identical test as both the pretest and the posttest (Salkind, 2010). This pre-post test was given to all of the students participating in the study, all of whom were taught the same standards. The instruction in both the treatment and the control group only varied as to the differentiated instruction by learning style that the treatment group received as described in the methods portion of this thesis. As Popham (2003) stated:

> The virtue of the classic pretest/posttest evaluative model is that, for the most part, it does measure the same group of students before instruction and after, meaning that a comparative analysis of the two sets of test data provides a clearer

> picture of the teacher's instructional impact on student mastery levels than do post-test data alone. (p. 151)

To strengthen the credibility of the pre-post test, a blind scoring model was used (Popham, 2003). The students were given the pretest and although the test was skimmed to summarize what skills the students may already possess, they were scored. Before the tests were stored, on the back of each test, as suggested by Popham (2003), an odd number was written to code each as a pretest. The control group's pretests was coded C1-C31 on the back and the treatment group's pretests was coded T1-T31. After the instructional plan was implemented and the post-test were given, these tests were coded in a similar manner, but with even numbers. The post-tests for both the control group and the treatment group were coded in the same fashion as the pretests were coded. The two sets of pretests and the two sets of posttest were combined together and then graded.

The questions were skill based in which students must be able to factor quadratic expressions and solve quadratic equations. In order to be fair to all students and as Popham (2003) stated, "...assessing them in a way that they are accurately measured" (p. 58), the questions were free from context and the directions asked students either to factor or to solve each quadratic given in the problem. Prior to the study, the panel read each question and was asked to approve only the questions that were free from bias so that no question was unfair, offensive, or had any disparate impact on any student or group of students (Popham, 2008).

To assess the students' knowledge of the process standards, the performance task was evaluated for each student using a rubric. To obtain construct validity, the

performance task was read to determine specific standards that should be assessed using the rubric as stated in the instructional plan. The panel reviewed the performance task to assure that the task does indeed correlate with the process standards outlined in the instructional plan. Although the products between the control group and the treatment group were different, they were tested and graded using the same exact task, answer sheet, and rubric. Even though pre-posttest in this model was not feasible for this assessment, such variables as instruction, setting, and time frame remained consistent for each student.

In order to determine if students learned the process standards that were addressed in the performance assessment, each student was provided an answer sheet to record answers and to organize their findings and a grading rubric (Popham, 2008). The grading rubric provided interval data to determine whether the process standards were learned by each student. The students could score a range of points in which four is optimal down to a minimal score of one. The students were scored on their ability to explain the problems, use of visuals, mechanics, demonstrated knowledge, and requirements. From these criteria, a valid score-based inference could be adequately made regarding a student's knowledge of the problem solving standards addressed (Popham, 2008).

As the task is lengthy and contextually complex, it was further reviewed by the panel of fellow employees for any bias. Koretz (2008) stated that, "a mathematics test that requires complex text and writing long answers may be biased against immigrant students who are competent in mathematics but have not yet achieved fluency in English" (p. 13). Although the task did not contain context that should offend any group,

disadvantages for students with low reading abilities, for example, could be penalized. The structured answer sheet should have alleviated some of the misunderstandings that may develop from reading comprehension difficulties. Also, the students could use their red cup to ask for help when needed. I restated the question and helped provide assistance to those who did not understand what they are reading. Goldstein (1996) discussed the difference between girls and boys when working on solving real-life problems and stated that girls are more contextual than boys, which can be a disadvantage when working with word problems that contain irrelevant details. In order to be fair to both girls and boys, the panel was asked to eliminate irrelevant details given in the task so that they could be eliminated.

To determine how student attitudes towards learning standards through problem solving who were grouped by learning style changed, four instruments were utilized: a note taking for reflective journal, reflective journal prompts, a Learning Style Survey, and a Student Problem Solving Attitudes Scale. All of these instruments were included in the instructional plan and read to ensure absence of bias.

Since validity "centers on the accuracy of the inferences teacher make about their students" (Popham, 2008, p. 52) attitudes towards problem solving, qualitative data were gathered using the note taking for reflective journal, the reflective journal prompts, and the learning style survey. Data collection was kept consistent in the amount of data and length of time collected between the treatment group and control group. The instruments utilized ensured that the raw data were maintained and well-organized.

A Pre-Post test titled ‘Student Problem Solving Attitudes Scale’ was also given to students in both the control and treatment group. The students were given ten questions and were asked to score each answer as: strongly agree, agree, disagree, or strongly disagree. The questions were worded so that when students chose ‘strongly agree’, they had a positive opinion in regards to problem solving and when students chose ‘strongly disagree’, they had a negative opinion and the other choices, ‘agree’ and ‘disagree’, fall in between. This likert scale pre-post survey provided ordinal data so that a comparison could be made to determine how the students’ attitudes towards problem solving differed between the control group and the treatment group. As Popham (2003) stated, “pretest/posttest contrasts of student’s attitudes, interests, or values as measured on self-reporting inventories are a final source of useful credible evidence regarding a teacher’s own instructional effectiveness” (p. 157).

Analysis of Data

To determine the implementation of differentiated instruction by learning style the data gathered through the instructional plan rubric and the interviews with the chosen panel was coded for recurring and dominant themes. Specifically, I looked for specific positive feedback, negative feedback/concerns, ideas from colleagues, any bias present, and items that needed to be added or deleted. The patterns formed by any repeating data were utilized to change the instructional plan in order to strengthen pedagogy.

To determine if there were significant differences between means from one group tested twice, each student’s score from both the control group and the treatment group from the pre- test to the post-test was compared using a dependent t-test. The null

hypothesis is that there is no significant difference between the pretest and posttest of either the treatment group or the control group. If the test were to show a significant difference between the pre-post test for either or both the treatment and the control group, we can reject the null hypothesis for the group or groups that showed the significant difference. The decision to reject the null was set at $p<.05$.

To determine if there were significant differences between the means from two independent groups, an independent T-test was used to compare the control group's and the treatment group's pre-post test (Salkind, 2007). The null hypothesis states that there is no significant difference in the pretests of the two groups. If there was no significant difference between the treatment group and the control group's pretests, then the null hypothesis could be accepted with a confidence of $p>.05$. A second null hypothesis was also formed in regards to the post-tests. In order to state that the treatment group benefited from being grouped by learning styles, the posttest would need to show the obtained value greater than the critical value and therefore, the null hypothesis could then be rejected. The decision to reject the null hypothesis was set at $p<.05$.

To determine if there were significant differences between the means from two independent groups, the performance task that was graded using a rubric and an independent t-test was used. If the treatment group performed better on the performance task and there was a significant difference, then the null hypothesis could be rejected with the decision to reject the null hypothesis set at $p<.05$.

Both the pre and post problem solving attitudes survey were analyzed using a Chi Square. This determined which questions regarding student attitudes towards problem

solving were significant and which were not. Significance was reported at the $p<.05$, $p<.01$, and the $p<.001$ levels.

Because the students took the attitudes scale survey by using a secret four digit code on the both the pre and post test, tests were matched up at the end of the study in order to better analyze the data through a dependent t-test. This test helped determine if there were significant differences between means from the one group tested twice. To prove the groups began with attitudes that were similar, the pretests would show no significant difference in the scores and the null hypothesis could be accepted with a decision set at $p>.05$. To determine if attitudes improved after students grouped for the problem-solving task by learning style, then the post-test should show a significant difference and the null hypothesis could be rejected. The decision to reject the null hypothesis was set at $p<.05$.

To test internal consistency reliability for the surveys, Cronbach's Alpha was also used each time the survey was given for both groups (pre and post). As Salkind (2010) stated, “you are actually correlating the score for each item with the total score for each individual, and comparing that to the variability present for all individual item scores” (p. 147). This analysis determined how closely the survey measured what it was designed to measure, i.e. student attitudes towards problem solving in groups.

The reflective journal, note taking instrument, and learning styles survey provided qualitative data that were coded for recurring and dominant themes in order to determine if attitudes towards learning standards through problem solving changed when students were grouped and received differentiated instruction by learning style. The note-taking

guide was used when observing the groups and gave pertinent feedback to decide how each group is positively responding to the task by measuring: if students were engaged in the task, worked cooperatively, and worked independently on a scale of 4– strongly agree down to 1-strongly disagree. There was also space provided to record actual quotes and specific behaviors observed. These quotes and behaviors were analyzed for any emerging themes as well.

This action research has been a process of obtaining consensual validation through the many necessary approvals obtained. Before this study began, my principal, the county school system, the faculty who assisted me with the study, and the LaGrange College Institutional Review Board approved the study and its design. To attain epistemological validation, I compared my results to my findings from the review of the literature. The similarities and differences from both qualitative and quantitative were analyzed to find any commonalities and to question when the data in my study opposed that of the literature.

Three types of credibility were attained throughout this study. To triangulate data sources, multiple qualitative and quantitative data sources were used that resulted in structural corroboration. Since opposing points of view were presented in the review of literature and were collected in the interview with the panel who reviewed my instructional plan and instruments, fairness was attained. Rightness of fit was also achieved because great care was taken to ensure precision and accuracy.

This action research was intended to possess referential adequacy. Not only should this action research increase personal growth, but also help to “build a strong

professional learning community" (Hendricks, 2009, p. 12). This referential adequacy gave this study transferability and therefore can be replicated by others easily to use for future research. In essence, regardless of the data outcomes, the knowledge gained can be applied to promote positive change. This catalytic validity not only transformed me, the researcher, but may also transform others who read this study.

CHAPTER FOUR: RESULTS

After the data were collected, the qualitative and quantitative data were analyzed and then organized by focus question. Since qualitative data can be "explained and used to answer research questions only after they have been interpreted" (Hendricks, 2009, p. 143), the qualitative data required "a deeper analysis of data than those processes used to explain quantitative data sources" (p. 143). To analyze the qualitative data, a thematic analysis was used by coding for themes such as, "relationships, activities, ways of thinking, and participants' perspectives" (Hendricks, 2009, p. 144). Hendricks (2009) suggested that quantitative data be analyzed using a software package such as SPSS and Excel. As suggested by Salkind (2010), the quantitative data were analyzed using Excel 2007.

After gathering data to determine how differentiating instruction by learning styles could be implemented in the classroom while students are learning state mandated problem solving standards, the instructional plan rubric and interviews were analyzed using qualitative methods prior to the implementation of the lessons included in the instructional plan. The demographically representative panel of employees scored the instructional plan 'highly effective' on the rubric and provided positive feedback in the following areas: 'essential question addresses enduring standard',' appropriate materials', 'alignment of task to standards', and 'free from bias'. When interviewed, the panel also responded positively to the formative assessments. The Math I regular education teacher, for example, commented that the formative assessments were effective and would "yield good qualitative data." The items that received mixed reviews from the panel, scoring either highly effective or effective were: 'appropriate use of

technology' and 'needs of special learners appropriately addressed'. When interviewed, the members of the panel agreed that there needed to be more strategies in place for someone who may have difficulty with the reading level. The administrator on the panel commented that the task seemed "high level and scaffolding may be needed to reach all learners." When I asked the Hispanic panel member if she thought that it was biased in any way, she said that, "it was okay, just a lot of reading." Negative feedback in regards to the task came from the special education teacher when she stated that, "the assignment is very wordy and may seem intimidating to special education students." Her suggestion was to "paraphrase when reading the directions and check for understanding with special education students." Lastly, the Math I teacher on the panel scored the 'appropriateness of the assessments to yield adequate data' as 'somewhat effective'. When interviewed, she defended this score by saying, "although the summative test will yield qualitative data for the treatment group and control group, due to the likelihood that visual learners may be better at paper and pencil tasks, the data may be skewed." The feedback received was taken into considerate and adjustments were made to the instructional plan.

The Learning Channel Preference questionnaire was given to students in the treatment group in order to determine each student's learning style. The category in which the student scored highest determined his/her learning style preference. After scoring each question, the students were instructed to circle the learning style category with the highest score. In the event of a two equally high scores, the students were instructed to select the learning style preference they preferred. Since there were ten questions per learning channel and the highest rating was a 3-'often applies', the closer the student's total score per category was to thirty, the stronger the learning style

preference. The lowest rating a student could give a question was a 0- 'never applies', therefore the closer the student's total per category was to a 0, the weaker the learning style preference. No student scored a thirty for any area. Student T22 scored the highest score for any area scoring a 28 in the kinesthetic category. Also, no student scored lower in any area than student T3, who scored a 5 in the visual category. Students T14, T17, T18, and T26 all had two scores that tied for highest score. The scoring of the Learning Preference questionnaire resulted in grouping the students as follows: auditory learners represented five groups of four students per group, visual learners represented one group of four, and kinesthetic learners represented one group of four.

Each student's total scores per category (auditory, kinesthetic, and visual) were analyzed by range (0 to 30) and standard deviation to measure the variability in the scores per student. For example, student T1, who totaled each of the three categories with an auditory score of 17, a kinesthetic score of 8, and a visual score of 13, had a range of 9 and a standard deviation of 4.5. When the ranges and standard deviations were analyzed, four emergent groups were present. The first group of students had a range of 3 or less and a standard deviation of less than or equal to 2.52 and represented 38% of the 28 students in the treatment group. Of the first group, there were three students- T4, T17, and T26 (which was 30% of the 37.7%) - who had two equally high scores for auditory and kinesthetic, and a visual score of only one or two points lower. Since the range and standard deviation were small, the first group was well represented in each of the learning channel categories. The second group of students had scores with ranges of 5 to 6, had a standard deviation between 2.65 and 3.79, and represented 25% of the students in the treatment group. Out of this 25% of students, 67% had two high scores that were only 1

to 2 point difference, and 33% who had a 3 to 6 point difference between the two higher scores. The students in the second group seemed to either have two learning channels that were well represented or one higher score and two somewhat lower scores that were close but still with high scores ranging from 17 to 21. A third group of students represented another 25% of the treatment group had ranges of 8 to 11 and a standard deviation ranging from 4.16 to 5.69. Of this third group, 71% had only 0 to 2 points difference in the two higher scores and 29% with only 3 to 4 points difference in the two higher scores. This group seemed to have two learning channels that were well represented while the third category was low with scores ranging from 8 to 15. Lastly, 12% of the students had a range of 12 to 19 and a standard deviation from 6 to 10.01. Seventy-five percent of the group had one high score (ranging from 20 to 28) and two lower scores (ranging from 5 to 15) and 25% (represented by student T24) scored a 24 in auditory, a 22 in kinesthetic, and a 10 in visual.

Quantitative methods were used to determine how students who were grouped by learning style differed from the students who were placed in random heterogeneous grouping. Unit pre-tests, unit post-tests, and performance task grades were analyzed to determine student learning outcomes. These results were used in order to incorporate the best practices from focus question one to the learning determined in focus question two.

As part of the instructional plan and in order assess prior knowledge, a pre-test was given to both the treatment group and the control group on the first day of the new unit, prior to any instruction of the standards. The null hypothesis stated that there was no significant difference between the treatment group's and the control group's pre-test. An independent t-test was run on the data. The results were $t(54)= 0.53$, $p>.05$ on a one

tailed test. Since the obtained value of 0.53 was less than the critical value of 1.67 (as shown in Table 4.1), then the null hypothesis should be accepted because there was no significant difference in the pre-test scores from the treatment group when compared to the pre-test scores of the control group. To determine "how different two groups are from one another" (Salkind, 2010, p.231) an effect size was calculated using Cohen's d and had an effect size of 0.14. Since this score is within the range 0.0 to 0.2, the effect size is considered small. Therefore, the groups tended to be similar (Salkind, 2010) and have an approximate overlap of 85%.

Table 4.1 – Independent t-test: Pre-test to Pre-test

t-Test: Two-Sample Assuming Equal Variances

	Pre-Test Treatment	*Pre-Test Control*
Mean	1.5	1.071428571
Variance	9.666667	8.142857143
Observations	28	28
Pooled Variance	8.904762	
Hypothesized Mean Difference	0	
Df	54	
t Stat	0.537373	
P(T<=t) one-tail	0.296609	
t Critical one-tail	1.673565	
P(T<=t) two-tail	0.593217	
t Critical two-tail	2.004879	

A dependent t-test was run on the treatment group's pre-to post-test to determine if there were significant differences between the means from one group tested twice. The null hypothesis was that there is no significant difference between the pre-test and the post-test of the treatment group. The results for the treatment group were t(27) = 22.

p<0.05. Since the obtained value of 22.0 was greater than the critical one-tail value of 1.70 (as shown in Table 4.2), the null hypothesis should be rejected because the difference in the pre-test scores when compared to the post-test scores of the treatment group is significant. An effect size was run and r = 0.94, proving a large effect size and, therefore, is a small percent of overlap. The Pearson's Coefficient of 0.20 from Table 4.2 showed a weak test-retest reliability of the unit test that was administered twice to the same group of students in the treatment group.

Table 4.2 – Dependent t-test: Pre-test to Post-test Treatment Group

t-Test: Paired Two Sample for Means

	Pre-Test Treatment	*Post-Test Treatment*
Mean	1.5	75.60714286
Variance	9.666666667	330.9880952
Observations	28	28
Pearson Correlation	0.203307445	
Hypothesized Mean Difference	0	
Df	27	
t Stat	-22.0019615	
P(T<=t) one-tail	4.47611E-19	
t Critical one-tail	1.703288423	
P(T<=t) two-tail	8.95221E-19	
t Critical two-tail	2.051830493	

Also, a dependent t-test was run on the control group's pre-to post-test to determine if there were significant difference between the means for one group tested twice. The null hypothesis was that there is no significant difference between the pre-test and the post-test of the control group. The results for the control group were t(27) = 14, p<0.05. Since the obtained value of 14.02 was greater than the critical value of 1.70 (as

shown in Table 4.3), the null hypothesis should be rejected because the difference in the pre-test scores when compared to the post-test scores of the control group is significant. An effect size was run and r = 0.88, proving a large effect size and, therefore, a small percent of overlap. The Pearson's Coefficient of 0.32 from Table 4.3, again showed a weak test-retest reliability of the unit test that was administered twice to the same group of students in the control group.

Table 4.3 – Dependent t-test: Pre-test to Post-test Control Group

t-Test: Paired Two Sample for Means

	Pre-Test Control	*Post-Test Control*
Mean	1.071428571	69.82142857
Variance	8.142857143	714.1521164
Observations	28	28
Pearson Correlation	0.32169528	
Hypothesized Mean Difference	0	
Df	27	
t Stat	-14.02069397	
P(T<=t) one-tail	3.25979E-14	
t Critical one-tail	1.703288423	
P(T<=t) two-tail	6.51958E-14	
t Critical two-tail	2.051830493	

In order to better determine how the students grouped by learning style differed from those students who were not, the post-tests were also used to compare the treatment and control group using an independent t-test. The null hypothesis stated that there was no significant difference between the treatment group's and the control group's post-test. An independent t-test was run on the data. The results were t(54) = 0.94, p>0.05 on a one

tailed test. Since the obtained value of 0.94 was less than the critical value of 1.67 (as shown in Table 4.4), the null hypothesis should be accepted because there is no significant difference in the post-test scores from the treatment group when compared to the post-test scores of the control group. To determine "how different two groups are from one another" (Salkind, 2010, p.231), an effect size was calculated using Cohen's d and equaled 0.25. Since this score is within the range 0.2 to 0.5, this is determined to be a medium effect size (Salkind, 2010) and to have an approximate overlap of 78%.

Table 4.4 – Independent t-test: Post-test to Post-test

t-Test: Two-Sample Assuming Equal Variances

	Post-Test Treatment	*Post-Test Control*
Mean	75.60714286	69.82142857
Variance	330.9880952	714.1521164
Observations	28	28
Pooled Variance	522.5701058	
Hypothesized Mean Difference	0	
Df	54	
t Stat	0.946997255	
P(T<=t) one-tail	0.173929409	
t Critical one-tail	1.673564907	
P(T<=t) two-tail	0.347858819	
t Critical two-tail	2.004879275	

An independent t-test was run on the grades the students received on their performance tasks to determine if there were significant differences between the means of the treatment group and the control group. The null hypothesis stated that there is no significant difference between the treatment group's and the control group's post-test. An independent t-test was run on the data. The results were $t(54) = 1.37$, $p>.05$ on a one

tailed test. Since the obtained value of 1.37 was less than the critical value of 1.67 (as shown in table 4.5), the null hypothesis should be accepted because there was no significant difference in the post-test scores from the treatment group when compared to the post-test scores of the control group. The effect size was determined to be 0.37 and using Cohen's d effect size ranges, the value falls within the range 0.2 to 0.5 and, therefore is determined to have a medium effect size (Salkind, 2010) with an overlap of approximately 72%.

Table 4.5 – Independent t-test: Performance Task

t-Test: Two-Sample Assuming Equal Variances

	Post-Test Task Treatment	*Post-Test Task Control*
Mean	85.17857143	88.53571429
Variance	42.59656085	123.3690476
Observations	28	28
Pooled Variance	82.98280423	
Hypothesized Mean Difference	0	
Df	54	
t Stat	-1.378922273	
P(T<=t) one-tail	0.086801966	
t Critical one-tail	1.673564907	
P(T<=t) two-tail	0.173603931	
t Critical two-tail	2.004879275	

To determine if attitudes towards learning standards through problem solving changed when differentiating instruction by leaning style, both the treatment group and the control took an attitudes pre-survey at the beginning of the study on the same day as the unit pre-test and an attitudes post-survey at the end of the study on the same day as the post-test. Since the survey used a Likert response scale, a Chi-Square was used on

each of the four sets of data (Pre-Survey Treatment, Post-Survey Treatment, Pre-Survey Control, and Post-Survey Control) to determine which question items were significant. The null hypothesis is the same for each question: the percentage of cases in category 1 (strongly disagree), category 2 (agree), category 3 (disagree), and category 4 (strongly disagree) is equal (Salkind, 2010). Table 4.6 and 4.7 show the results of the chi-square pre-survey and post-survey for both the treatment group and the control group.

Table 4.6 – Chi Square: Student Problem Solving Attitudes Scale Treatment

N = 28	Pre-Survey Treatment	Post-Survey Treatment
1. I am confident in my ability to solve word problems.	27.71429***	24.85714***
2. I am confident in my ability to communicate mathematically.	27.71429***	20***
3. I am confident in my ability to use math outside of the classroom.	16.28571***	29.42857***
4. I am confident in my ability to represent mathematics in multiple ways.	25.42857***	21.42857***
5. I enjoy learning new math concepts through word problems.	16.57143***	11.71429**
6. Word problems help me understand math standards that I am learning.	11.14286*	9*
7. I enjoy learning about math with real-life examples.	17.42857***	12.85714**
8. When I am solving word problems, I prefer to work in a group.	23.42857***	22***
9. Problem solving is an important part of mathematics.	36.28571***	38.28571***

10. I think that there is more than one way to solve a math word problem.	26.57143***	21.42857***

P< .05*, P<.01**, P<.001***

Table 4.7 – Chi Square: Student Problem Solving Attitudes Scale Control

N = 28	Pre-Survey Control	Post-Survey Control
1. I am confident in my ability to solve word problems.	26***	49.42857***
2. I am confident in my ability to communicate mathematically.	18***	13.42857**
3. I am confident in my ability to use math outside of the classroom.	16.85714***	29.42857***
4. I am confident in my ability to represent mathematics in multiple ways.	28***	6.857143
5. I enjoy learning new math concepts through word problems.	20.28571***	6.571429
6. Word problems help me understand math standards that I am learning.	34.85714***	14**
7. I enjoy learning about math with real-life examples.	28.28571***	43.71429***
8. When I am solving word problems, I prefer to work in a group.	25.42857***	23.42857***
9. Problem solving is an important part of mathematics.	26.57143***	38.28571***
10. I think that there is more than one way to solve a math word problem.	28***	21.42857***

P< .05*, P<.01**, P<.001***

The results of the chi-square statistic for the treatment group's pre-test and post-test and the control group's pre-test determined all of the questions to be significant at

either the .05, 0.01, or 0.001 level and therefore the null hypothesis can be rejected, meaning that there is a significant difference in the answers given for each question and the expected outcome could not be expected to occur by chance. The results of the chi-square statistic for the control group's post-test determined that questions 4 and 5 were not significant; therefore the null hypothesis which states that there is no significant difference between the way in which the students answered and what could have happened by chance was observed must be accepted. The remaining questions for the control group's post-test were found to be significant at the .01 or .001 level and the null hypothesis is rejected.

To determine the test-retest reliability of the surveys, students used a secret four digit code so that the data could be analyzed using dependent and independent t-tests. When the students took the post-test survey, only 19 of the 28 students from the treatment group and 24 of the 28 students from the control group were able to remember their four digit codes. Only these scores were analyzed in the Tables 4.8-4.11.

As shown in Table 4.8, the comparison of the pre-survey between the control and treatment groups, an independent t-test yielded the obtained value of 0.17, which is less than the critical value of 1.68; $t(41) = 0.17$, $p>0.05$. The null hypothesis was accepted at the .05 level, which states that there is no significant difference between the two groups tested. The effect size was calculated using Cohen's $d = 0.05$, therefore there is close to 100% overlap and the groups are highly similar.

Table 4.8 – Independent t-test: Pre-test to Pre-test Survey

t-Test: Two-Sample Assuming Unequal Variances

	Pre-Test Survey Treatment	*Pre-Test Survey Control*
Mean	28.36842105	28.54166667
Variance	9.023391813	13.99818841
Observations	19	24
Hypothesized Mean Difference	0	
Df	41	
t Stat	-0.168416201	
P(T<=t) one-tail	0.433541975	
t Critical one-tail	1.682878003	
P(T<=t) two-tail	0.86708395	
t Critical two-tail	2.019540948	

The dependent t-test of the Pre-to-Post Survey of the Treatment group from Table 4.9 shows that the obtained value is 0 and the critical value 1.73, therefore $t(18) = 0$, $p>0.05$. Since the obtained value is less than the critical value, the null hypothesis is accepted indicating no significant difference between the pre-test and post-test of the treatment group. The effect size was calculated at $r = 0$; therefore, there is approximately 100% overlap and the groups are highly similar. The Pearson Correlation as shown in Table 4.9 is equal to 0.58 which gives the test-retest reliability higher than a medium range.

Table 4.9 – Dependent t-test: Pre-test to Post-test Survey Treatment Group

t-Test: Paired Two Sample for Means

	Pre-Test Survey Treatment	*Post-Test Survey Treatment*
Mean	28.36842105	28.36842105
Variance	9.023391813	11.13450292
Observations	19	19
Pearson Correlation	0.589840679	
Hypothesized Mean Difference	0	
Df	18	
t Stat	0	
P(T<=t) one-tail	0.5	
t Critical one-tail	1.734063592	
P(T<=t) two-tail	1	
t Critical two-tail	2.100922037	

Table 4.10, Dependent t-test: Pre-test to Post-test Survey Control Group, shows that the obtained value is 1.64 and the critical value 1.71, therefore, $t(23) = 1.64$, $p>0.05$. Since the obtained value is less than the critical value, the null hypothesis is accepted with no significant difference between the pre-test and post-test of the control group. The effect size was calculated at $r = 0.34$, therefore there is much less overlap when compared to the treatment group with an effect size of $r = 0$. The test-retest reliability, as indicated by the Pearson Correlation, is equal to 0.46, indicating a slightly weaker correlation than the treatment group's survey.

Table 4.10 – Dependent t-test: Pre-test to Post-test Survey Control Group

t-Test: Paired Two Sample for Means

	Pre-test Survey Control	*Post-test Survey Control*
Mean	28.54166667	29.83333333
Variance	13.99818841	13.62318841
Observations	24	24
Pearson Correlation	0.46019851	
Hypothesized Mean Difference	0	
Df	23	
t Stat	-1.638699462	
P(T<=t) one-tail	0.057442399	
t Critical one-tail	1.713871517	
P(T<=t) two-tail	0.114884797	
t Critical two-tail	2.068657599	

As shown in table 4.11, Independent t-test: Post-test to Post-test Survey, since the obtained value of 1.36 was less than the critical value of 1.68, the null hypothesis was accepted at a .05 level; $t(40)= 1.36$, $p>.05$. The null hypothesis was accepted which states that there is no significant difference between the two groups tested. The effect size was calculated using Cohen's d = 0.41, which is a medium effect size.

Table 4.11 – Independent t-test: Post-test to Post-test Survey

t-Test: Two-Sample Assuming Unequal Variances

	Post-Test Survey Treatment	*Post-test Survey Control*
Mean	28.36842105	29.83333333
Variance	11.13450292	13.62318841
Observations	19	24
Hypothesized Mean Difference	0	
Df	40	
t Stat	-1.363869541	
P(T<=t) one-tail	0.090117398	
t Critical one-tail	1.683851014	
P(T<=t) two-tail	0.180234796	
t Critical two-tail	2.02107537	

The Cronbach's Alpha test was conducted to determine internal consistency reliability of the items for the survey. As Salkind (2010) stated, internal consistency reliability, "is used when you want to know whether the items on a test are consistent with one another in that they represent one, and only one, dimension, construct, or area of interest" (p. 147). The tests showed moderately higher than a medium correlation. The Cronbach's Alpha computations for the survey are as follows: pre-survey treatment $\alpha = 0.68$, post-survey treatment $\alpha = 0.61$, pre-survey control $\alpha = 0.75$, and post-survey control $\alpha = 0.76$.

In addition to the pre-and post-problem-solving attitudes survey, qualitative were gathered through a reflective journal, note taking instrument, and a learning style survey. These data provided more evidence of how student attitudes towards problem solving in

groups changed when differentiating instruction by learning styles. The data were analyzed by coding for both recurring and dominant themes.

Question 1 on the learning style survey asked, "…do you feel you are a better problem solver, a worse problem solver, or about the same kind of problem solver you were before working in the learning style cooperative group?". The second part of the question asked the students to defend their answer. Out of the 28 students who were questioned on the anonymous survey, 50% responded 'better', 46% responded 'same', and 4% responded 'worse'. The students who responded that they felt they were a better problem solver provided similar responses which included themes such as, "I understand things more", "using my style of learning with other people helped me understand the problems better", and "I got to explore my learning style more and working with other people who share my learning style was a great help…". The students who responded 'same', responded similarly for example, "…the project neither helped my skills nor hurt them extensively", "I still use the same thought process to think through problems", "I still got confused and then I would get it. Just like if I was learning in cooperative". The one student who represents the 4% with a response of 'worse' stated, "not having anything to look at or help me made it hard."

Question 2 asked the students, "Has participating in the learning style group changed the way you feel about problem solving?" Of the 28 students who took the survey, 36% responded 'yes' and 64% responded 'no'. Question 3 asked the students, "Has participating in the learning style group changed the way you feel about problem solving on real life problems?" The students responses to question 3: 36% responded 'yes' and 64% responded 'no'. From questions 2 and 3, 43% of the students answered

‘yes’ for one of the two questions and ‘no’ for the other questions, showing that the 36% who responded ‘yes’ for question 2 was not the same group who answered ‘yes’ for question 3 and likewise for the set of students who answered ‘no’ for each question.

The remaining five questions were open-ended questions which asked the students to provide feedback as to what activities were most beneficial, least beneficial, could be done for improvement, and what comments they have that weren’t specifically asked on the survey. The recurring positive themes that were present in the student responses and the number of students who responded that way out of the 28 students surveyed are as follows: “the questions being read aloud” (3), “talking about the problems out loud”(4), “the cups”(2), “being grouped with others that learn the same way I do” or just “groups” (5), “reading the problems repetitively”(2), “puzzles” (3), “I don’t know” or left it blank (12). The recurring negative themes were not as prevalent and varied more from student to student. The following quotes best fits the sample followed by the number of responses: “the question not being read aloud” or “talking with my group” (5), “no visual aids” (3), “where we stood up and explained it” (1), “I think I was in the wrong learning style” (1), no response or “none” (16). The suggestions received by the students and the number who responded that way are: “the teacher reads” or “more one on one” (3), “more visual representation of the word problems” (3), “more examples and working groups” (5), “talk about problems more” (2), “need both visual and auditory” (2), “variety” and “more games” (3).

The reflective journal and note taking instrument were used to provide data during observations while the treatment and control group were working on the task. During the first two days of the task, the groups from both the treatment group and the control group

frequently used their red cups and teacher assistance was needed for all groups. When the majority of the groups had displayed the red cup for teacher assistance, the entire class was addressed and the problems were discussed as a whole. By the third day, the students were able to work more interdependently and needed less teacher assistance. The trend during the entire study was that for any given day, the treatment group had 3 out of 7 groups who would responded positively to the task by engaging in the task and working cooperatively and without teacher assistance, whereas 4 out of the 7 responded positively to the task in the control group with the same criteria. The groups who responded positively or negatively on a given day varied more in the treatment group. Treatment group 2, for example, had three good days of discussion on the task, and then seemed to have problems staying motivated and would get frustrated and would become quiet, seeming just to stare at the task for long periods of time. The class atmosphere when listening to the treatment groups was much quieter in general than listening to the groups from the control group. Group 7, a kinesthetic treatment group, responded more positively to the task than any of other learning style groups and made the most positive comments when observed, stating: “I wish we could always be grouped by our learning style because this really helps me.” When the treatment group was observed a few days before the students were to present their findings for the two questions assigned to their group, the visual group, the kinesthetic group, and one of the auditory groups responded positively to the task and were engaged by respectively making a poster, making a puzzle, and discussing questions to type-up. The control group was also observed and 5 out of the 7 groups were actively engaged in making posters and discussing their answers. Overall, for any given day of the task, more groups from the control group were

talking about the task and needed less encouragement from the teacher to remain engaged when compared to the students from the treatment group.

CHAPTER FIVE: ANALYSIS AND DISCUSSION OF RESULTS

Analysis of Results

In order to fully triangulate the results of the data found in the previous chapter, both the qualitative and quantitative data required further interpretation to improve pedagogy. Nastasi and Schensul (2005) stated that, "qualitative research techniques are essential for documenting the adaptations necessary for application of interventions to real-life contexts and for identifying core intervention components which are related to desired outcomes" (as cited by Leech & Onwuegbuzie, 2007, p. 558). By further interpreting the results from the quantitative data, internal validity will be strengthened and will determine the "degree to which results are true for the participants" (Hendricks, 2009, p. 111).

To determine how differentiating instruction by student learning styles can be implemented in the classroom while students are learning problem solving, an instructional plan was created and reviewed by a panel which consisted of two teachers, an administrator, and parent. Feedback the panel provided through a rubric and through interviews provided both positive and negative feedback. The negative feedback mainly pertained to a need to provide more accommodations for special education students. Because none of the students from either the control group or the treatment group requires accommodations, the recommendation was noted and may be needed in the future for another semester. The reading involved in the task was also noted as a negative theme. The instructional plan was changed so that the difficulty of the task was

taken into consideration and students who needed extra assistance were given help when needed.

Northey (2005) suggested the Learning Channel Preference Questionnaire that was used in my study. The questionnaire was vital to my study because this instrument was intended to accurately interpret a student's learning style or channel. What this study did not anticipate was that most students scored about the same score in each area with only a few points between the scores. Many students had two high scores. Because there were only 10 questions to answer per learning channel and each total varied by only 30 points, the scores were close in number. With only one or two points difference between the scores, it showed that the students were not strong in one learning style, but more of an even mixture of all three or at least two of the learning channels.

The interval data from the unit pre-and post-tests provided evidence as to whether students who were grouped by learning style differed from students who were grouped in randomly selected cooperative groups. Since the obtained value was less than the critical value, these values provided evidence that there were no significant differences between the treatment group and the control group's pretests on a dependent t-test. The effect size for the comparison of the two sets pre-tests was also small and further established that the groups were nearly identical at the beginning of the study. The pre-and post-tests for both the treatment group and the control group had significant gains using an independent t-test and had a large effect size which showed both groups had learned the knowledge from pre-to post-test. When the post-tests were compared from the two groups, the null hypothesis was accepted and it was determined that the score on unit tests of students who worked in groups by learning style did not have significant gains

when compared to the scores of students who worked in cooperative groups. The effect size of 0.25 had increased from the effect size of the pre-test to post-test of 0.14, which shows the groups to have less overlap and to be less similar than they were at the beginning of the study.

Because the Pearson Correlation was not determined to be significant (Mahoney, 2010), a weak test-retest reliability was found evident. The score was obtained in both of the pre-post dependent t-tests with values of 0.2 and 0.32. Although the panel corroborated that the test only contained questions that aligned with the standards, I think that the test-retest reliability could have been strengthened by adding more questions with more variety. The test that was used was made up of only 17 free response questions.

The performance task was also scored for both the treatment and control group and analyzed using an independent t-test. The independent t-test revealed that there was not a significant difference between the two groups and the null hypothesis was accepted. The test also showed a medium effect size of 0.37. This shows that the students who were grouped by learning style neither positively nor negatively differed from the student who were grouped cooperatively.

The Chi Square was used to determine which of the Pre-Post Survey questions were significant and which ones were not for both treatment and control groups (see Tables 4.6 and 4.7). All of the questions were significant for the treatment group at a .05, .01, or .001 levels and most were at the .001 level. All of the questions, except questions 4 and 5 were significant for the same levels for the control group. Even though the test shows that the control group students did answer the same way, a closer analysis shows

that this was only an indicator of positive attitudes for the task for all questions except numbers 4 and 5. Question four states, “I am confident in my ability to represent mathematics in multiple ways.” and question five states, “I enjoy learning new math concepts through word problems.” For both the treatment and the control group, the students responded negatively on the pre-and-post test to question six at significant levels. The students for both groups also responded negatively at significant levels to question 5 on the pre-test, but only the treatment answered negatively at significant levels to question five on the post-test.

Students who had successfully used their secret four digit code on their pre-survey and post-survey attitude scales could be further analyzed using a dependent and independent tests. The tests were run on 19 of the 28 treatment group surveys and 24 of the 28 control group surveys. The tests showed that there were no significant gains for any test run. The treatment group in particular answered the same way for both the pre-test and the post-test with an effect size of 0, showing no difference in the students’ attitudes before and after the treatment. The control groups’ obtained value and critical value were closer in value and had a greater effect size of 0.34 which showed some difference in the groups. The student attitudes in the control group did improve from pre-test to post-test because the frequency of positive responses increased from pre-to post-test on the Chi Square.

The Pearson’s Coefficient provided evidence that the survey was reliable with scores of 0.58 for the pre-survey to post-survey of the treatment group and 0.46 for the pre-survey to post-survey of the control group. To provide further internal reliability, a Cronbach’s Alpha test was used to determine if the entire treatment group or the control

group answered in a similar manner on either or both of the pre-post surveys (Mahoney, 2010). The alpha scores revealed slightly higher than a medium correlation to moderately higher than medium ranging from 0.61 to 0.76.

The learning style survey also provided qualitative data to answer this study's third focus question that was concerned with student attitudes. As Leech and Onwuegbuzie (2005) stated, "…qualitative data can be used to strengthen quantitative research designs in general and intervention research designs" (p. 560). A constant comparison, or coding, was used to "chunk" the data into "smaller and meaningful parts" (Leech & Onwuegbuzie, 2005, p. 565). Almost half of the students responded positively and half of the students reported no change at all, previously revealed in the student surveys. As Mahoney (2010) stated, "though this result was not anticipated, it was not believed to have negative implications for the student attitudes…", I tended to analyze the data in the same manner. Although the students did not respond as positively as originally anticipated, the students also did not report many negative effects of the study. It was evident that the majority of the surveys containing the most positive responses were from the kinesthetic learners because the surveys mentioned hands on activities that were only offered to the kinesthetic learners. This qualitative data shows that the kinesthetic group benefited from the learning style grouping more than the other groups.

The qualitative data provided from my teacher note-taking guide and reflective journal suggest that the students in the control group responded slightly more positively to the task than the treatment group because there were more control groups observed on task for any given day than treatment groups.

As noted in the literature review, students can be resistant to new instructional methods (Aaronsohn, 2003). The students in the treatment group could have responded in a negative or in a neutral way because they were resistant to change. Lawrence-Brown (2004) stated one of the three criteria for differentiating instruction was to promote active learning though multiple presentations. Because the students were grouped by learning style, the students may have been at a disadvantage because they could have received a richer set of 'multiple' presentations if they were not all presented through one learning style. The students even responded this way in their questionnaire and made suggestions for other presentations that could be used. Also, Solomon (1998) suggested that cooperative groups be organized heterogeneously. Even though the students were not grouped by ability, grouping students by learning style may have inhibited them from being true heterogeneous groups. Dunn, Beaudry, and Klavas (2002) stated that "learning style is a biologically and developmentally imposed set of personal characteristics that make the same teaching method effective for some and ineffective for others. Every person has a learning style- it's an individual as a signature." (p. 75). However, my findings did not correlate with these authors. The results of the study showed that most of the students relied equally on each of the learning styles as determined on the learning style survey. All but three students were well represented in at least two of the three categories, and two of those three were kinesthetic learners. Instead of students having 'a' learning style as suggested in the literature, they needed all three learning styles.

Discussion

One possible reason why the research produced the results was that students are resistant to change. A student even stated on his questionnaire, "Our group just sat there and solved them like we would do normally." By the time students are in high school, they have been trained that their learning should be done a certain way and can be resistant to new ideas. Another student corroborated this resistance to change when he/she candidly stated, "teach to learn and leave out the over –the-top activities…doesn't help."

The results from the pre-survey and post-survey attitudes scales showed a few questions that all students answered negatively. With students responding negatively to both questions 4 and 5, it is possible that the wording of these questions influenced the responses. Question 4 could be changed to, "I am confident in my ability to solve math problems in different way…". If question 5 were not taken out completely changing the wording might help as "enjoy" is a term that was too extreme for this survey. Either deleting or rewording questions 4 and 5 would increase the reliability of this survey.

The most striking result/product of the reason why students did not show a positive change when differentiated instruction by learning styles was utilized in cooperative groups is the finding that most students are likely to be equally strong in at least two out of the three learning style areas and, therefore, do need multiple representations in order to maximize learning. Since the majority of the students scored nearly equal in all of the three learning style categories, the students would have most

likely performed just as well in any of the three learning style groups. This finding was not anticipated and offers an interesting perspective for further research.

The findings contribute to knowledge and to practice by providing evidence that differentiating by learning style in which students are afforded opportunities to work with one learning style does not improve learning of problem solving standards or attitudes towards problem solving. The study is relevant because improving student problem solving skills is transferable to any grade level or any subject. Although the study did not conclude as was expected, much knowledge was gained regarding learning styles and the importance of students being provided with multiple representations when problem solving. Also, kinesthetic learners responded more positively to the task most likely because ordinarily their learning style is not well represented in the math class. Understanding the importance of providing pathways of learning for kinesthetic learners and taking deliberate measures in the planning stages of a unit would ensure kinesthetic learners are provided with an appropriate representation of the curriculum.

Structural corroboration was attained by using multiple qualitative and quantitative sources. Opposing points of view were presented through the literature and qualitative data was used in order to ensure fairness. Because the qualitative and quantitative data support the same findings, rightness of fit was ensured to provide gained knowledge regarding grouping students by learning style when working on problem solving in groups.

Implications

The data analyzed to determine whether grouping students by learning style could be advantageous in their learning or their attitudes towards problem solving provided a strong case against grouping by learning style to improve pedagogy. A major theme that was reinforced is that most students enjoy working in groups and responded positively to this in both the treatment groups and the control groups. This study has referential adequacy because this study could be replicated for any performance task by any teacher wanting to test how students perform when grouped by learning style.

After the study, the students have more of an appreciation of different types of learning styles, understand more how they learn using the learning style language, and appreciate receiving various types of presentations to new learning. For example, after the study, students used their gained knowledge of their learning style and asked me if they could learn a motion (something I did with the kinesthetic group) to help remember a factoring technique. Catalytic validity was attained because this study has transformed me as a teacher by empowering me to look more closely at different methods of differentiated instruction. This study has also given me a deeper understanding of how the importance of giving students different methods of learning so that students see it, hear it, and relate to it physically.

Impact on Student Learning

After the literature was reviewed and synthesized for best practices, the instructional plan was written, reviewed, and taught accordingly. This process positively impacted student learning because the curriculum was strong in both content and process

(Vacca, Vacca, & Mraz, 2011). Student learning has improved because of the findings of this study. After this study, students are more aware of the different learning styles and feel more confident in utilizing all three learning styles to gain knowledge. This study gave my students agency in their learning and gave them a voice in the classroom. My students asked more questions and use the language of 'visual', 'auditory', and 'kinesthetic' to explain another way that the information might need to be presented. After this study, I am more aware of the three different learning styles and better understand the importance of making sure to present new material in all three styles. After the study, I deliberately incorporate methods for reaching all learning styles into my lesson plans to ensure I do not revert to a traditional teaching style model.

Recommendations for Future Research

For future research, I would recommend that if students are grouped by learning style, that the groups should be flexible groups. If students could have been able to change from one learning style to another, the students would have received representations from all three learning styles and the groups may have differed more from the control group and given more to compare. Also the students in the control group should be given a questionnaire at the end of the study to compare with the treatment group's responses.

The unit test did not provide a strong Pearson Coefficient and was not reliable; therefore, I would use a different unit test. Also, I would leave out two of the questions on the attitudes survey to strengthen reliability of the survey. I would recommend using a

different more in-depth test for students to find their learning style. The learning style survey I used did not do a good job indicating a student's strongest learning style.

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Appendix A

Instructional Unit Plan

Quadratic Investigations

15-20 days

The Lesson:

Paula's Peaches Learning Task is 10 pages long with 15 sets of questions. The plan is to spend 45 minutes of each 90 minute block on the performance task. The students should be able to finish one set of questions per day; therefore, the task should take the students 15 days of class time to complete. Each group will choose two sets of questions to present. Since are 15 sets of questions, I may need to present one set – or if there are 8 or more groups, then some groups can just have one of the longer question sets and will count as two. The rest of the time in the block will be used to assess, discuss, and work on the standards of this task – using direct instruction and independent work.

Essential Questions:

1. How do you solve and model real life problems using polynomial arithmetic?
2. How do I use the zero-product property to solve a quadratic property?
3. How do you represent a trinomial as the product of two linear binomials?
4. How does the solution of a quadratic equation relate to its graph?

Instructional Technology:

Graphing Calculators – at least one per group – task requires

Computer – optional – as a resource if students need further information on a topic

Video Camera – optional – students may choose to present by using video (for treatment group only)

LCD projector/computer – used to present any work student has made on video or power point (for treatment group only)

Internet – students may need to research a question further, define a word, used as an available resource

Materials:

1. Copy of Performance Task, "Paula's Peaches" , one per person
2. Paula's Peaches answer sheet
3. Treatment Group – Learning Style Menu – gives options per learning style to present the learned standards
4. Grading rubric for performance task
5. Graph Paper and straightedges
6. Graphing Calculators – as listed under instructional technology
7. Chart Paper and markers
8. Textbook
9. Colored pencils
10. Notebook paper and pencils
11. Scientific calculator
12. Whiteboard and markers
13. Each group one set: one green, one yellow, and one red plastic cup

Accommodations for special needs:

- Extra time, if needed
- Extra tutoring available after school
- Notes provided, when needed
- Extra probes when needed (example, given the formula for area of a rectangle as a probe for writing quadratics as the area of two linear binomials)
- Any accommodations per IEP will be implemented

Standards Covered:

Math I Algebra Standards:

MM1A2e: Students will factor expressions…(x + a)((x + b) = x^2 + (a + b)x +ab

MM1A3a: Students will solve quadratic equations in the form ax^2 +bx + c = 0 where a =1, by using factorization and finding square roots where applicable.

Math I Process Standards:

MMP1: Students will solve problems (using appropriate technology).

MM1P3: Students will communicate mathematically.

MM1P4: Students will make connections among mathematical ideas and to other disciplines.

MM1P5: Students will represent mathematics in multiple ways.

Assessment (formative):

1. Warm-up: given daily – will review any previous knowledge needed for that days task

    Example: the students must decide on day one if the relationship between the number of trees per acre and the average yield in peaches per tree is a linear relationship or not and then write a formula that expresses the relationship. The Warm-up for that day would be: A student is going to join a new music plan. It is twenty dollars to sign up for a year and then fifty cents for every downloaded song. If you join, how much would it cost to purchase 1 song, 10 songs, 20 songs? Graph your results – let the number of songs be the x-axis and the cost be the y-axis. (This would lead to a discussion that would help them with the questions in performance task.)

2. Homework: student will receive homework questions that pertain to the questions asked in the performance task.
3. Group presentations – groups will present a set of questions to the class - At this point, teacher can guide discussions, pose questions, and assess student knowledge.
4. Ticket out the Doors: students will receive a 'ticket out the door' each day – The question will help guide instruction the next day. If students did not understand the concept, for example, why the domain when x was equal to the number of peach trees was whole numbers greater than or equal to 30, then more time would need to be spent reviewing domain.

Assessment (summative):

1. The students will be given a pre-test and then the same test as a post-test at the end of the unit. The test will assess the algebra standards listed above.
2. The students will be assessed on the task using a rubric.

Relevancy to children:

The task is relevant to children because the students are able to see quadratic applicable to a real-life problem. Paula, who is a peach grower in central Georgia, wants to expand her peach orchard. Although, it may seem like a simple peach farm, the students quickly discover that the algebra involved is more than just a few simple calculations. They will need to factor and a quadratic to help Paula figure out, for example, if she can plant less than 30 trees and still yield 600 peaches per tree. This discovery performance task is rich in algebra and will make it necessary for them to think and discuss cooperatively.

Control Group vs. Treatment Group:

1. **Content –** the content for both control and treatment groups will be the same – same standards for both group
2. **Process and Methods**:

The treatment group will be divided into subgroups by learning style. Each student will take a learning style survey to determine his/her learning style. Each sub-group will consist of three to four students.

The control group will be divided randomly into subgroups. The sub-groups will also consist of three to four students. In order to foster cooperative learning, students may be changed from one group to another by teacher discretion.

The control group and the treatment group will be given a teacher written pretest . The student names will be coded C1-C31 for the control group and T1-T29 for the treatment group and the scores will be recorded in excel to be used at a later date. The students in both groups will also take a student problem solving attitude survey. The students will create a 4 digit code so they can be scored anonymously, while allowing me to pair each student’s answers with the post survey. The Paula’s Peaches performance task (on the GaDOE website), Paula’s Peaches answer sheet, and the grading rubric will be handed out to every student.

The students in the control will be grouped randomly into sub-groups of three to four students in which they are to work cooperatively. Each sub-group will be assigned at least one question to present to the class and will be given a piece of chart paper that is poster-board-size on which to write their answers. The students in the treatment group will take a Learning Channel Survey, and a Learning Conditions Survey. The students will be grouped according to their learning style in groups of three to four students. The students will be assigned at least one question to present to the class and will be given a Learning Style Menu to choose how they will present their answer.

Both the sub-groups in the control group and the treatment group will receive one yellow, one red, and one green cup. When the students are working well on the task, the students will display the green cup. When a group begins to have trouble understanding a portion of the task, they will then display the yellow cup and will first discuss the issue with the other group members and define the problem. When the group agrees that teacher assistance is needed, the group will then display the red cup. At this time, I will assist the group with their problem with the task.

The treatment sub-groups who are grouped by learning style will be categorized and referred in class as either a visual learner group, an auditory learner group, or a kinesthetic learner group. In addition to each learning style group being provided with a Learning Style Menu to differentiate the product that will prove the understanding of the standards, each treatment sub-group will be provided process differentiation through varied instructional techniques that is catered to their learning style.

As suggested in the literature, the visual learner groups will begin each day with five to ten minutes of silent reading . The visual will be provided with ear plugs to use during the silent reading. To provide more visual interaction with the visual learners, when they use their red cups to alert teacher assistance, the students will be asked to present the question in written form and the answer to the question will be also given in written form. The students will then choose one of three visual learner options from the Learning Style Menu to present their answers to at least one of the fifteen questions that will randomly assigned to their group.

The auditory learners will begin each day with five to ten minutes of listening to the task be read aloud either by the teacher or from a pre-recorded source (Dunn & Dunn, 1993). The auditory learners will be encouraged to talk about the task at great length before answering the questions on the answer sheet. When the auditory learner sub-group displays the red cup for assistance, they will be asked to verbally ask the question and then assistance will be provided through a verbal exchange a rich discussion of the problem instead of written form (Dunn & Dunn, 1993).

Kinesthetic Learners will begin each day reading the new portion of the task that will be cut into sections and pasted onto a task card. The material will look different, but will be the exact same material, just pasted onto task cards in order to provide more access of the task for the kinesthetic learner (Dunn, Beaudry, and Klavis, 2002). When the kinesthetic learners use the red cup for assistance, they will be shown the answer by making up some movement or visual. An example would be having the student show the shape of the quadratic with their arms.

When the sub-groups of the control group present the red cup for assistance, I will listen to their questions and look for the work they have on the Paula's Peaches Learning Task Answer Sheet and answer questions through verbal response and ask them to write those responses down.

During each class block for fifteen days, forty five minutes will be spent on the task and the presentations as a group finishes. At the end of the three weeks, students from the control group submit in the Paula's Peaches answer sheet and will be graded using the rubric for the problems that were assigned to the group. The students in the treatment group will be graded for problems they were assigned by the same rubric but on what they chose to present from the learning style menu.

Both treatment and control groups will take a posttest identical to the pretest. They will also take the problem solving attitude survey again and use the same four digit code that was provided on the initial survey.

Grouped Differently:

Control Group: Students will be assigned randomly to a cooperative group.

Treatment Group: Students will be given a learning-styles survey. Students will be scored and will be grouped accordingly to their learning style.

3. **Product:**

Performance Task: Both the control group and the treatment group will be graded on their products using the same rubric – showing knowledge of the same standards as listed above. The products, however, will be different. The control group will be graded using the Paula's Peaches Answer Sheet for the assigned problems for that group. The product of the treatment group will be tailored to their learning style and will also be graded for the one or two problems that were assigned to that group. For example, the students who are in a kinesthetic group might present the information by doing a skit.

Test: Both groups will receive the same pre-post test

Appendix B

Peer-review Instructional Plan Rubric:

Question	**4-highly effective**	**3- effective**	**2- somewhat effective**	**1-not effective**
Do the essential questions address an enduring standard?				
Are the materials used appropriate for the task?				
Is the technology used adequate for the task?				

Are the needs of special learners addressed?				
Do the assessments align with the standards stated?				
Are the most appropriate assessments used to yield adequate data?				
Are the assessments free from bias?				

Appendix C

Unit 5 Math I Test: Factoring and Solving Quadratics

Name:___________________________________
Class:__________________________Date:__________

Use the zero-product property to solve the equation.

1. $(x + 4)(x - 2) = 0$
2. $(x + 3)^2 = 0$

Factor the expression.

3. $x^2 + 3x + 2$
4. $x^2 - x - 6$
5. $x^2 - 7x + 10$
6. $x^2 + x - 12$
7. $x^2 - 9$
8. $x^2 - 8x + 16$
9. $x^2 + 6x + 9$
10. $2x^2 - 4$

Solve the equation.

11. $x^2 - 2x - 3 = 0$
12. $x^2 + 5x + 6 = 0$
13. $x^2 + 3x - 4 = 0$
14. $x^2 - 6x + 5 = 0$
15. $x^2 - 36 = 0$
16. $x^2 + 12x + 36 = 0$

Appendix D

Student Problem Solving Attitudes Scale

Students, please complete this attitude scale. Please make up a 4 digit code that you can remember and keep secure. You will use this code again at the end of the unit to take another survey. It is important that you are honest in your responses.

4 digit secret code: ____ ____ ____ ____

1. **I am confident in my ability to solve word problems.**

   Strongly agree agree disagree strongly disagree

2. **I am confident in my ability to communicate mathematically.**

   Strongly agree agree disagree strongly disagree

3. **I am confident in my ability to use math outside of the classroom.**

   Strongly agree agree disagree strongly disagree

4. **I am confident in my ability to represent mathematics in multiple ways.**

   Strongly agree agree disagree strongly disagree

5. **I enjoy learning new math concepts through word problems.**

   Strongly agree agree disagree strongly disagree

(turn over – more questions on the back)

6. **Word problems help me understand math standards that I am learning.**

Strongly agree agree disagree strongly disagree

7. I enjoy learning about math with real-life examples.

Strongly agree agree disagree strongly disagree

8. When I am solving word problems, I prefer to work in a group.

Strongly agree agree disagree strongly disagree

9. Problem solving is an important part of mathematics.

Strongly agree agree disagree strongly disagree

10. I think that there is more than one way to solve a math word problem

Strongly agree agree disagree strongly disagree

Appendix E

Performance Task Answer Sheet

Answer Sheet **Name______________________**
Paula's Peaches Learning Task

<u>Peaches per tree</u>
1.a. Linear or nonlinear. Explain:
b. Yield per tree for 6 more trees.__________

c. Yield per tree for 42 trees per acre.__________

d. x = number of trees planted on each acre

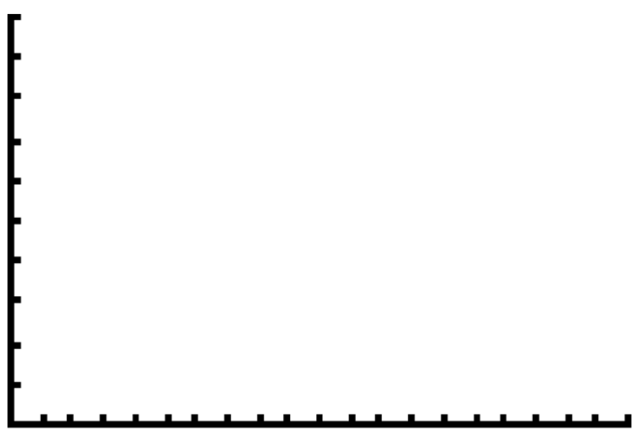
T(x)=Average yield per tree

T(x)=______________ Simplest form for T(x)=__________________

Explain how this formula is correct:

e.

	(x)



domain =________

.

2. Total Peaches Per Acre

a. 30 trees per acre yields ____________peaches per acre.	e. Average rate of change in peaches per acre as trees per acre increases from 36-42. ______________
b. 36 trees per acre yields _____________peaches per acre.	f. The relationship between number of trees per acre and yield in peaches per acre is linear/nonlinear.
c. 42 trees per acre yields _____________peaches per acre.	g. Y(x) = ________________ Expanded form_______________ h. Y(30)=_________ Y(36)=___________ y(42)=___________ How are these related to a-c?
d. Average rate of change in peaches per acre as trees per acre increases from 30-36. ______________	i. Are the domains for T and Y related? Yes or no. Explain:

3. Paula's Orchard

a. Total yield for 30 acres = same total with x trees per acre	________________________=_________________
b. Make one side of the equation be 0.	___________________=0
c. Is there a greatest common factor? Yes or no. GCF__________	
d. Multiply both sides by a rational number so that a is 1.	________________________=0
e. In standard form, b=________, c=_________	
f. List all m and n values such that m * n = c. Find the pair such that m + n = b ___________	
g. Write the equation in (x+m)(x+n) form.	_(_________)(_________)=0
h. Now set each of the factors equal to 0 and solve for x	____________=0 ______________=0
i. Verify the x values in h are solutions.	
j. Explain the meaning of the solutions in the context of the problem:	

4. Neighboring Orchard

a. Write an equation for 14,400 peaches per acre total yield	_______________________=14,400
b. Make one side of equation 0	_______________________=0
c. Multiply both sides by the rational number so that a is 1	_______________________=0
d. In standard form, b=_______,	

c=________	
e. List all the m and n values such that m*n=c Find the pair such that m + n = b________	
f. Write the equation in (x+m)(x+n) form.	g. (_________)(_________)=0
h. Now set each of the factors equal to 0 and solve for x	____________=0 ______________=0
i. Verify the x values in h are solutions.	
j. Are the solutions in the domain of Y? yes or no. How many trees are planted to get a yield of 14,400?	

5. Factored Form. Include the rectangle to model the product.

a. $x^2 + 3x + 2$

e. $x^2 + 8x + 12$

b. $x^2 + 6x + 5$

f. $x^2 + 13x + 36$

c. $x^2 + 5x + 6$

g. $x^2 + 13x + 12$

d. $x^2 + 7x + 12$

6. Factoring with negative b and positive c. Verify by multiplying the factors.

a. $x^2 - 8x + 7$

e. $x^2 - 11x + 24$

b. $x^2 - 9x + 18$

f. $x^2 – 11x + 18$

c. $x^2 – 4x + 4$

g. $x^2 – 12x + 27$

d. $x^2 - 8x + 15$

7. Factoring with +/-b and negative c. Verify by multiplying the factors.

a. $x^2 + 6x - 7$

d. $x^2 - x – 42$

b. $x^2 - 6x -7$

e. $x^2 + 10x - 24$

c. $x^2 + x -42$

f. $x^2 - 10x – 24$

8. Solving Quadratics

Equation	**Factor**	**Solve**	**Check**
a. $x^2 – 6x + 8 = 0$	( )( )=0		
b. $x^2 – 15x + 36 = 0$			
c. $x^2 +28x +27 = 0$			
d. $x^2 – 3x – 10 = 0$			

e. $x^2 + 2x – 15 = 0$			
f. $x^2 – 4x – 21 = 0$			
g. $x^2 – 7x = 0$			
h. $x^2 + 13x = 0$			

9. Use Addition Property of Equality and Multiplication Property of Equality to write equivalent equations. Try to factor and solve each equation. Check results.

Equation/Equivalent Equation = 0	**Factor**	**Solve**	**Check**
a. $6x^2 + 12x - 48 = 0$	( )( )=0		
b. $x^2 – 8x = 9$			
c. $3x^2 = 21x - 30$			

d. $4x^2 + 24 = 20x$			
e. $x(x-11) + 30 = 0$			
f. $\frac{1}{2} x(x + 8) = 10$			
g. $(x + 1)(x + 5)+3=0$			
h. $(x + 5)^2 = 49$			
i. $(2x+3)(x+4)=x+24$			
j. $5x(x + 3) = 200$			

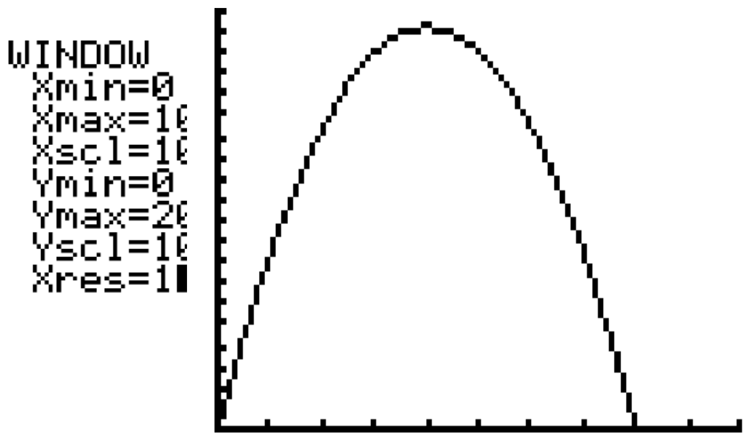
Back to Peach Growers in Central Georgia.

10. How many trees per acre would produce 8400 peaches?

11. No peach trees would yield 0 peaches. Is there another case with more than 30 trees when the yield would also be 0?

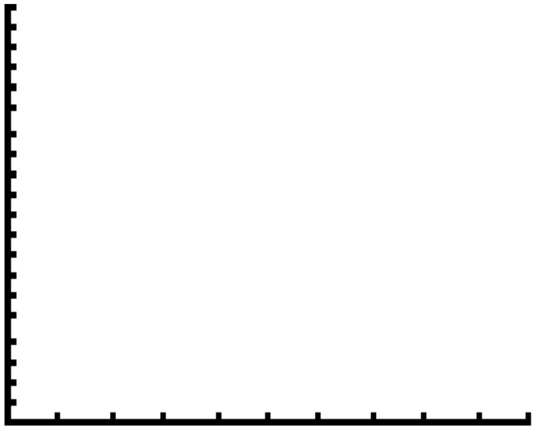
12. How many trees would produce 19,200 peaches?

13.



x	f(x)
	18,000
	18,000
	14,400
	14,400
	8400
	0
	19,200

x	Y(x)
	18,000
	18,000
	14,400
	14,400



a. Plot points for 3 and 4 j.

b. Plot points for 10, 11, 12.

c. What is the relationship between the graph of f and the graph of Y?

d. What points are on f, but not on Y. _________________

e. How do the graphs show the difference in the domains?

14. a. Draw the line y = 18000 on the graph for 13. Where is the intersection with Y? _____________

How many trees per acre give a yield of more than 18,000 peaches per acre?

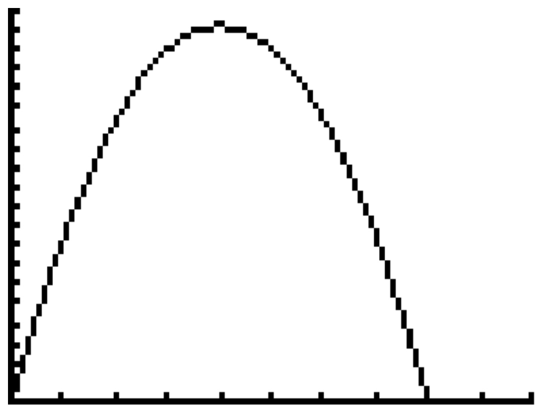
____

b. Draw the line y=8400 on the graph. Where is the intersection with Y?___________________

How many trees per acre give a yield of fewer than 8400 peaches per acre?__________________

c. Use a graphing utility or the graph below to find the number of trees per acre for each yield value.

# of trees	Total Yield	**d. Calculated yield for number of trees using Y**
	10, 000	
	15, 000	
	20, 000	



15. a. Complete the table for the equations solved in #8.

b. Mark the points that represent the solutions.

Equation	Graph
e. $x^2 + 2x - 15 = 0$	
f. $x^2 - 4x - 21 = 0$	
g. $x^2 - 7x = 0$	
h. $x^2 + 13x = 0$	

c. How are these points an example of the intersection method explored in problem #14?

Geometric Representation

Appendix F

Product Grading Rubric:

Name____________________

Performance Task_______________________________

	4	3	2	1	points
Explanation	A complete response with a detailed explanation	Good solid response with clear explanation	Explanation was unclear	Misses key points	
Use of visuals	Clear diagram or sketch with some detail	Clear diagram or sketch	Inappropriate or unclear diagram	No diagram or sketch	
Mechanics	No math errors	No major math errors or serious flaws in reasoning	May be some serious math errors or flaws in reasoning	Major math errors or serious flaws in reasoning	
Demonstrated Knowledge	Shows complete understanding of the questions, mathematical ideas, and processes	Shows substantial understanding of the problem, ideas, and processes	Response shows some understanding of the problem	Response shows a complete lack of understanding for the problem	
Requirements	Goes beyond the requirements of the problem	Meets the requirements of the problem	Hardly meets the requirements of the problem	Does not meet the requirements of the problem	
				Total:	

Appendix G

Learning Channel Preference

Name:_____________________________ Date:________________________

Read each sentence carefully and consider whether or not it applies to you.

3 – often applies 2 – sometimes applies 1 – almost never applies 0 – never applies

Add up the numbers and the channel with the highest score is your learning channel preference.

A Channel_______________

____1. When I read, I listen to the word in my head or read aloud.

____2. To memorize something, it helps me to say what I am trying to learn over and over to myself.

____3. I need to talk about things to understand them.

____4. I don't need to take notes in class.

____5. I remember what people have said, better than what they were wearing.

____6. I like to record things to listen to on tape.

____7. I'd rather hear a lecture on something rather than have to read about it.

____8. I can easily follow a speaker even when I am not watching the speaker talk.

____9. I talk to myself when I'm solving a problem or writing.

____10. I prefer to have someone tell me how to do something rather than to read the directions for myself.

_____ A Total

B Channel_________________________

_____1. I don't like to read or listen to directions; I'd rather just start doing.

_____2. I learn best when I am shown how to do something and then have the opportunity to do it.

_____3. I can study better when music is playing.

_____4. I solve problems more often through trial-and-error, rather than using a step-by-step approach.

_____5. My desk and/or locker look disorganized.

_____6. I need frequent breaks while studying.

_____7. I take notes but never go back to read them.

_____8. I do not become easily lost, even in strange surroundings.

_____9. I think better when I have the freedom to move around; I have a hard time studying at my desk.

____10. When I can't think of a specific word, I'll use my hands a lot and call something a "thing-a-ma-jig"

_____ B Total

C Channel_________________________________

____1. I enjoy doodling and even my notes have lots of pictures, arrows, and other marks on them.

____2. I remember something better if I write it down.

____3. When I am trying to remember a telephone number, or something new, it helps me to picture it in my head.

____4. When I am taking a test, I can "see" the textbook page and the correct answer on it.

____5. Unless I write down directions, I am likely to get lost or arrive late.

____6. It helps me to look at the person speaking. It keeps me focused

____7. I can clearly picture things in my head.

____8. It's hard for me to understand what a person is saying when there is background noise.

____9. It's difficult for me to understand a joke when I hear it.

____10. It's easier for me to get work done in a quiet place.

____ C Total

Key: Channel A – Auditory Learner, Channel B – Kinesthetic Learner, Channel C – Visual Learner

Northey, S.S., (2005). *Handbook on differentiated instruction for middle and high schools*. Larchmant, NY: Eye on Education Inc.

Appendix H

Learning Style Menu:

Each group will be assigned one of the eight problem sets from "Paula's Peaches". You must present your information to the class. Choose one of three options that are given for your learning style. Use the grading rubric provided when planning your product.

Auditory	Kinesthetic	Visual
Plan and lead a discussion with the class. Make up five questions that promote thinking.	Write and perform a skit and perform the skit to the class – revealing the answer to the assignment.	Provide typed notes and answers to the problem you were given.
Make a video recording your findings.	Write and conduct an interactive game that includes entire class – provide questions and answers.	Make a poster showing the solutions to your assigned problem.
Make a song or wrap that reveals the answer to your assigned problem.	Make up a dance that you perform to show the answers to your assigned problem.	Make a colorful diagram/mind map that presents the data in an organized way.

Appendix I

Note taking for reflective journal: Date:

Circle: Treatment Group/Control Group:

Codes: 4 – strongly agree, 3- agree, 2- disagree, 1- strongly disagree

Group #	Observation #1	Observation#2	Observation #3	Observation #4
Students were engaged in the task	Score- Notes –	Score- Notes-	Score – Notes-	Score – Notes -
Group worked cooperatively	Score- Notes –	Score- Notes –	Score- Notes –	Score- Notes –
Students worked without much assistance from teacher(use	Score- Notes –	Score- Notes –	Score- Notes –	Score- Notes –

cups)				
Students responded positively to the task	Score- Notes –	Score- Notes –	Score- Notes –	Score- Notes –

Appendix J

Reflective Journal Prompts

Date:

Strategy applied to treatment group:

1. Were the students engaged in the task?

Treatment Group- grouped by learning style	Control Group- grouped randomly

2. Did the groups work cooperatively?

Treatment Group- grouped by learning style	Control Group- grouped randomly

3. Were the students able to work without much assistance from the teacher?

Treatment Group- grouped by learning style	Control Group- grouped randomly

4. Did the students respond positively to the task?

Treatment Group- grouped by learning style	Control Group- grouped randomly

5. What did I learn from the four observations above?

6. What was the best part of this session?

7. What are my concerns regarding this session and student learning?

8. What would I do differently next time?

Appendix K

Learning Style Survey

Students, please complete this survey on learning styles. Answer each question, and provide as much information as you can on the open-ended questions. It is important to be honest in your answers because I will use the information you provide to help me plan for future problem solving lessons. You do not have to put your name on this survey. Thanks for helping me with this important project. Mrs. Westbrook

1. After participating in your learning style group, do you feel you are a better problem solver, a worse problem solver, or about the same kind of problem solver you were before working in the learning style cooperative group?

   (circle one) Better Worse Same

   Why?

2. Has participating in the learning style group changed the way you feel about problem solving in school? (circle one) Yes No

   If yes, how has it changed the way you feel about problem solving in school?

3. Has participating in the learning style group change the way you feel about problem solving on real life problems? (circle one) Yes No

4. What activities geared toward your learning style have been the most helpful to you?

5. What activities geared toward your learning style have been the least helpful to you?

6. How can we improve the activities that were geared toward your learning style?

7. Is there anything else you would like to say about grouping by learning styles? If so, please write your comments here.

Adapted from (p. 103): Hendricks, C., (2009). *Improving schools through action research*. Upper Saddle River, New Jersey: Pearson Education, Inc.